6.1 Hanford Groundwater Monitoring Project

D. R. Newcomer and M. J. Hartman

The strategy for managing and protecting groundwater resources at the Hanford Site was recently presented in DOE/RL-98-48, Draft C and DOE/RL-98-56. The strategy focuses on protection of the Columbia River, protection of human health and the environment, treatment of groundwater contamination, and limitation of contaminant migration from the 200 Areas. Implementation of the strategy includes continued monitoring of groundwater quality through the Hanford Groundwater Monitoring Project. The project is designed to detect new contaminant plumes and to document the distribution and movement of existing groundwater contamination. Monitoring provides the historical baseline for evaluating current and future risk from exposure to groundwater contamination and for deciding on remedial options. Hydrogeologic studies are an integral part of the project because the geology and hydrology of the site control the movement of contaminants in groundwater.

The effort to protect groundwater quality at the Hanford Site is being implemented through programs to minimize wastes being discharged to the soil column and through site remediation activities. The Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement; Ecology et al. 1989) provides a framework for remediation of the Hanford Site, including groundwater, over a 40-yr period. A summary of accomplishments in waste minimization and site remediation is presented in Section 2.3, "Activities, Accomplishments, and Issues."

DOE prepared a *Plan and Schedule to Discontinue Disposal of Liquids Into the Soil Column at the Hanford Site* (DOE 1987), which includes an alternative for treatment and disposal of contaminated effluents discharged to the soil. Of the 33 major waste streams identified in DOE (1987), the Phase I (higher-priority) streams have either been eliminated or are being treated and diverted to the 200 Areas Treated Effluent Disposal Facility. In addition, process condensate from the 242-A Evaporator is treated at the 200 Areas Effluent Treatment Facility and then discharged to the 616-A Crib (also known as the State-Approved Land Disposal Site) north of the 200-West Area. The State-Approved Land Disposal Site is the only facility at Hanford that received radionuclide-bearing liquid effluent discharged to the soil column in 1998. The locations of active permitted facilities are shown in Figures 1.0.2 and 6.1.1 and are discussed in detail in Section 2.3, "Activities, Accomplishments, and Issues." All other facilities (e.g., cribs, trenches) that historically discharged liquid waste to the soil column are out of service. The only operational injection wells are associated with pump-and-treat remediation systems. Disposal of liquids to soil has been significantly reduced during the last several years. For example, in 1987, >23 billion L (6 billion gal) of liquid effluents were discharged to the soil. This was reduced to approximately 4.9 billion L (1.3 billion gal) in 1995 and <0.9 billion L (<240 million gal) in 1998. In 1998, approximately 10% of the liquid volume was discharged to the State-Approved Land Disposal Site and approximately 90% was discharged to the 200 Areas Treated Effluent Disposal Facility.

Groundwater is used for drinking water and other purposes at a few locations on the Hanford Site. DE&S Hanford, Inc., DynCorp Tri-Cities Services, Inc., and Pacific Northwest National Laboratory monitor drinking water supplies at the point of use or

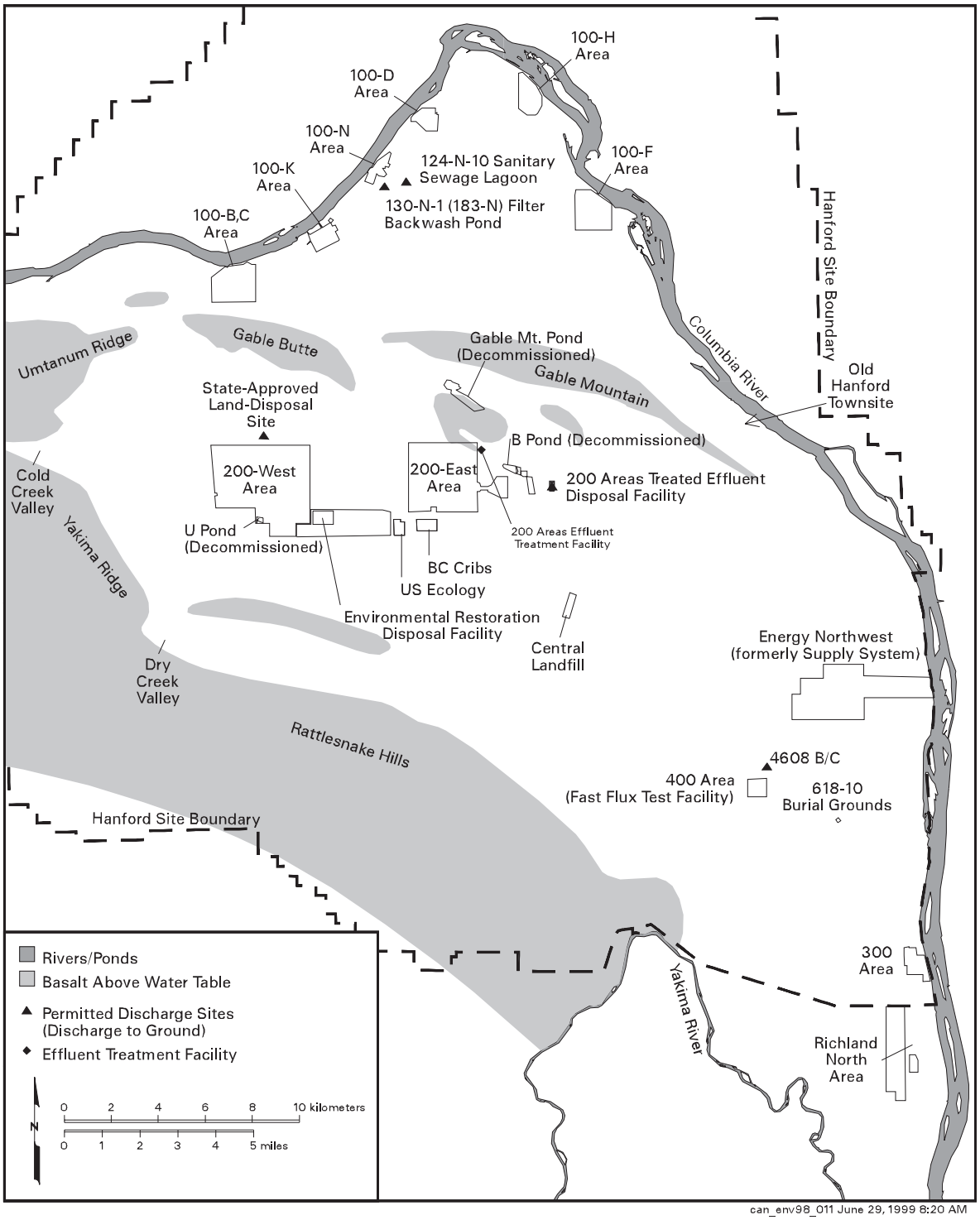


Figure 6.1.1. Active Liquid Wastewater Discharge Sites at Hanford

at the source. DynCorp Tri-Cities Services, Inc. monitors for nonradiological constituents and DE&S Hanford, Inc. and Pacific Northwest National Laboratory monitor for radiological constituents. Results of the radiological monitoring are summarized in Section 4.3, "Hanford Site Drinking Water Surveillance." The locations of wells completed in the unconfined aquifer that provide water for drinking, fire suppression, and cooling are shown in Figure 6.1.2.

6.1.1 Geologic Setting

The Hanford Site lies within the Pasco Basin, one of several structural basins within the Columbia Plateau. Principal geologic units beneath the Hanford Site include, in ascending order, the Columbia River Basalt Group, the Ringold Formation, and the Hanford formation (informal name) (Figure 6.1.3).

The Columbia River basalts were formed from lava that periodically erupted from volcanic fissures. The regional river system eroded the basalt and deposited sediments across the basalt surfaces between eruptions. Zones between the basalt flows and the sediments deposited as interbeds between basalt eruptions are frequently water bearing zones that are used as water sources in areas around the Hanford Site.

During the period of basalt deposition, tectonic pressure was very slowly deforming the basalt flows into the generally east-west trending ridges that border the Pasco Basin today. After the last major basalt eruption, sand and gravel of the Ringold Formation were deposited in the central portion of the Pasco Basin by the ancestral Columbia River as it meandered back and forth across the relatively flat basalt surface. Following uplift of the basalts and overlying sediments, the Columbia River began to erode, rather than deposit, sediments in the Pasco Basin. The uppermost mud layer was eroded from much of the Pasco Basin, and a caliche layer, part of the Plio-Pleistocene unit, developed in places on the eroded surface of the Ringold Formation.

More recently, the Hanford formation sediments were deposited by catastrophic ice age floods. Fine sands and silts were deposited in slackwater areas at the margins of the basin. However, primarily sand and gravel were deposited on the Hanford Site. In places, these sediments are covered by up to a few meters (feet) of recent stream or windblown deposits.

More-detailed information on the geology of the Pasco Basin can be found in BHI-00184, DOE/RW-0164 (Vol. 1), PNNL-12086 (Section 3.1), WHC-MR-0391, WHC-SD-EN-TI-014, and WHC-SD-EN-TI-019.

6.1.2 Groundwater Hydrology

Both confined and unconfined aquifers are present beneath the Hanford Site. An aquifer is a water-saturated geologic interval or unit that has a high permeability, meaning it can transmit significant quantities of water. A confined aquifer is bounded above and below by low-permeability materials that restrict the vertical movement of water. The confining layers may be dense rock, such as the central parts of basalt flows, silt, clay, or well-cemented sediments. Areally extensive, confined aquifers at the site are found primarily within interflows and interbeds of the Columbia River basalts. These are referred to as basalt-confined aquifers. Locally confined aquifers are also found below the clays and silts of the Ringold Formation.

An unconfined aquifer, or water-table aquifer, is overlain by unsaturated sediments. The upper surface of the saturated zone in an unconfined aquifer,

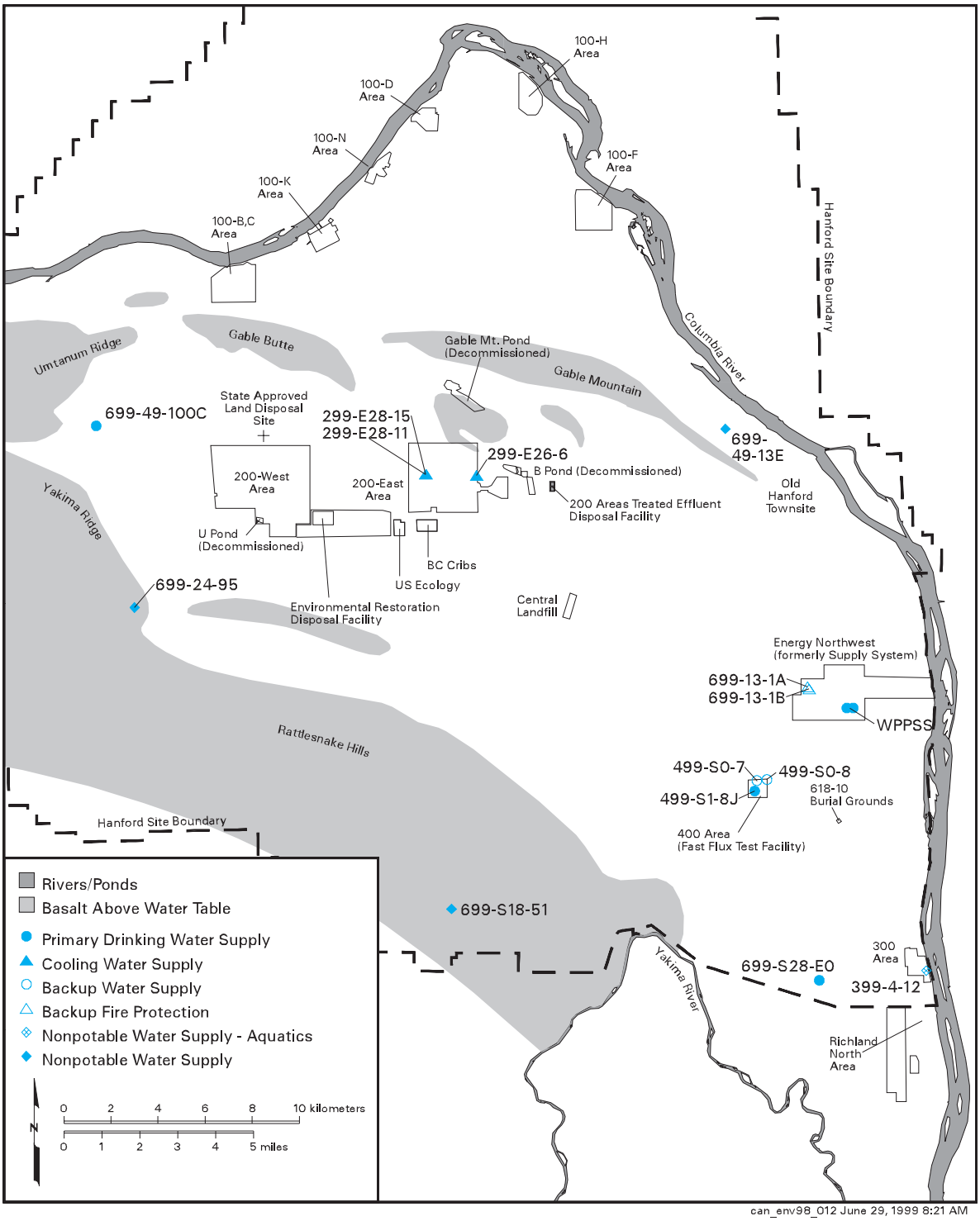


Figure 6.1.2. Water Supply Wells in the Unconfined Aquifer

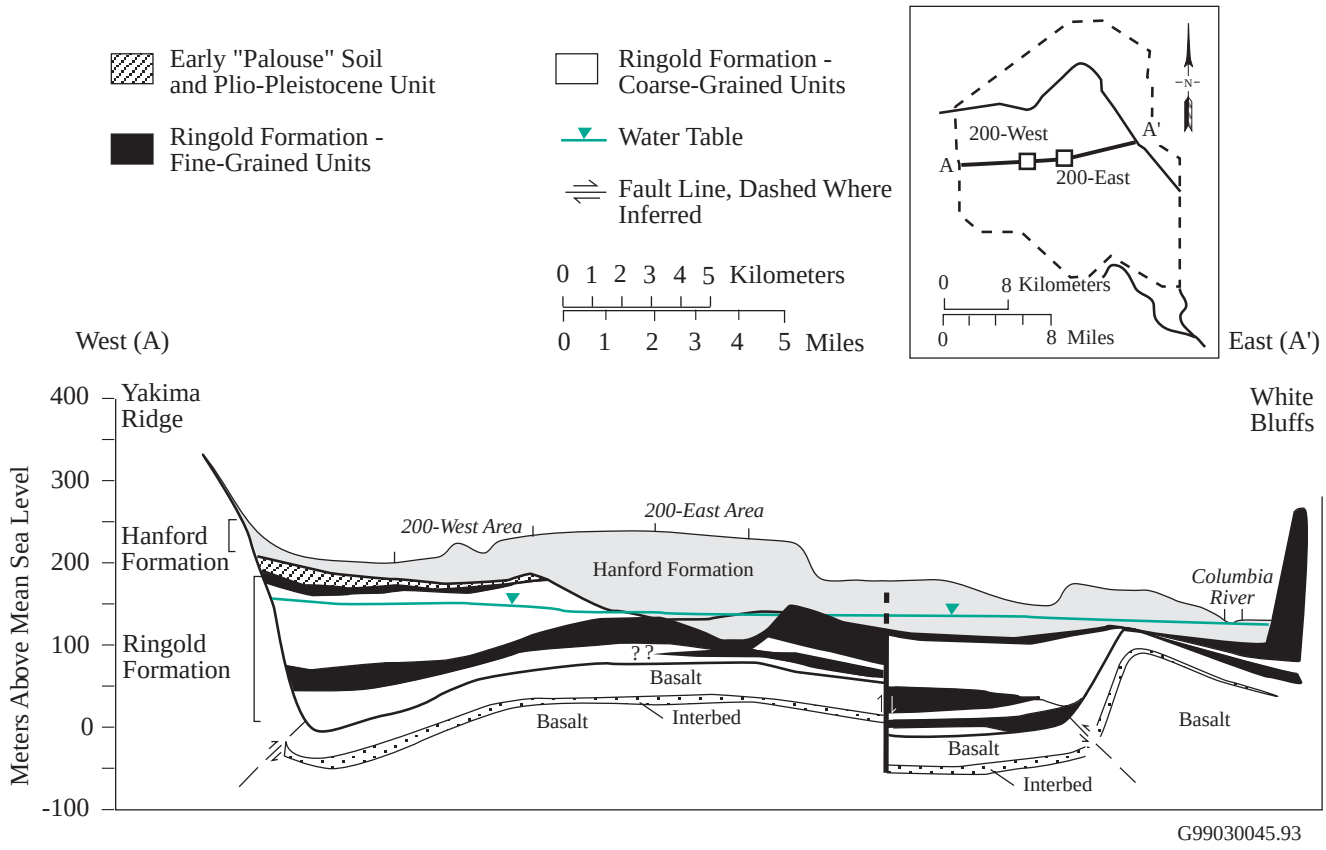


Figure 6.1.3. Geologic Cross Section of the Hanford Site

which is called the water table, rises and falls in response to changes in the volume of water stored in the aquifer. In general, the unconfined aquifer at the Hanford Site is located in the Hanford and Ringold Formations. In some areas, the water table is below the bottom of the Hanford formation and the unconfined aquifer is entirely within the Ringold Formation. The Hanford formation sands and gravels are unconsolidated and are generally much more permeable than the compacted and silty Ringold Formation gravels. Clay and silt units and zones of natural cementation form low-permeability zones within the Ringold Formation.

The unconfined aquifer forms the uppermost groundwater zone and has been directly impacted by wastewater disposal at the Hanford Site. The unconfined aquifer discharges primarily into the Columbia River and is the most thoroughly monitored aquifer beneath the site. The Rattlesnake Ridge interbed is the uppermost, basalt-confined aquifer within the Pasco Basin and the Hanford Site. This aquifer and other confined aquifers are generally isolated from the unconfined aquifer by dense rock that forms the interior of the basalt flows. However, interflow between the unconfined aquifer and the basalt-confined aquifer system is known to occur at faults that bring a water bearing interbed in contact with other sediments or where the overlying basalt has been eroded to reveal an interbed (Newcomb et al. 1972, RHO-RE-ST-12 P, WHC-MR-0391). Additional information on the basalt-confined aquifer system can be found in PNL-10158 and PNL-10817.

The thickness of saturated sediments above the basalt bedrock is >200 m (656 ft) in some areas of the

Hanford Site and thins out along the flanks of the uplifted basalt ridges (Figures 6.1.3 and 6.1.4). Depth from the ground surface to the water table ranges from <0.3 m (1 ft) near the Columbia River to >106 m (348 ft) in the center of the site. The unconfined aquifer is bounded below by either the basalt surface or, in places, by relatively impervious clays and silts within the Ringold Formation. The water table defines the upper boundary of the unconfined aquifer. Laterally, the unconfined aquifer is bounded by basalt ridges and by the Yakima and Columbia Rivers. The basalt ridges have a low permeability and act as a barrier to the lateral flow of groundwater where they rise above the water table (RHO-BWI-ST-5, p. II-116).

The water-table elevation contours shown in Figure 6.1.5 indicate the direction of groundwater flow and the magnitude of the hydraulic gradient in the unconfined aquifer. Groundwater flow is generally perpendicular to the water-table contours from areas of higher elevation, or head, to areas of lower head. Areas where the contours are closer together are high-gradient areas, where the "driving force" for groundwater flow is greater. However, because sediments with low permeabilities inhibit groundwater flow, producing steeper gradients, a high gradient does not necessarily mean high groundwater velocity. Lower transmissivity and steeper gradients are often associated with areas where the water table is below the bottom of the Hanford formation and the aquifer is entirely within the less-permeable Ringold sediments. Figure 6.1.6 shows the generalized distribution of transmissivity as determined from aquifer pumping tests and groundwater flow model calibration. Additional information on aquifer hydraulic properties at Hanford is presented in DOE/RW-0164 (Vol. 2) and PNL-8337.

Recharge of water within the unconfined aquifer (RHO-ST-42) comes from several sources. Natural recharge occurs from infiltration of precipitation along the mountain fronts, runoff from intermittent streams such as Cold and Dry Creeks on the western margin of the site, and limited infiltration of precipitation on the site. The Yakima River, where it flows along the southern boundary of the site, also recharges the unconfined aquifer. The Columbia River is the primary discharge area for the unconfined aquifer. However, the Columbia River also recharges the unconfined aquifer for short periods during high-river stage, when river water is transferred into the aquifer along the riverbank. Recharge from infiltration of precipitation is highly variable on the Hanford Site both spatially and temporally. The rate of natural recharge depends primarily on soil texture, vegetation, and climate (Gee et al. 1992, PNL-10285) and ranges from near zero, where fine-grained soils and deep-rooted vegetation are present, to >10 cm/yr (4 in./yr) in areas where soils are coarse textured and bare of vegetation.

Large-scale, artificial recharge to the unconfined aquifer occurred as a result of liquid waste disposal in the operating areas and offsite agricultural irrigation to the west and south. Discharge of wastewater caused the water table to rise over most of the Hanford Site. Local areas with elevated water tables are called groundwater mounds. Figure 6.1.7 shows the change in water-table elevations between 1944 and 1979, when the water table had stabilized over most of the site. Figure 6.1.8 shows the water table decline between 1979 and 1995, when many waste streams were consolidated and wastewater discharge was reduced. The greatest decline in the water table occurred in the 200-West Area and is discussed below. The water table continues to decline over much of the Hanford Site, as illustrated by Figure 6.1.9, which shows the water-level changes between 1997 and 1998.

Two major groundwater mounds formed in the vicinity of the 200-East and 200-West Areas in response to wastewater discharges. The first of these mounds was created by disposal at the 216-U-10 Pond (U Pond) in the 200-West Area. After U Pond was decommissioned in 1984, the mound slowly dissipated and has become much less distinct over

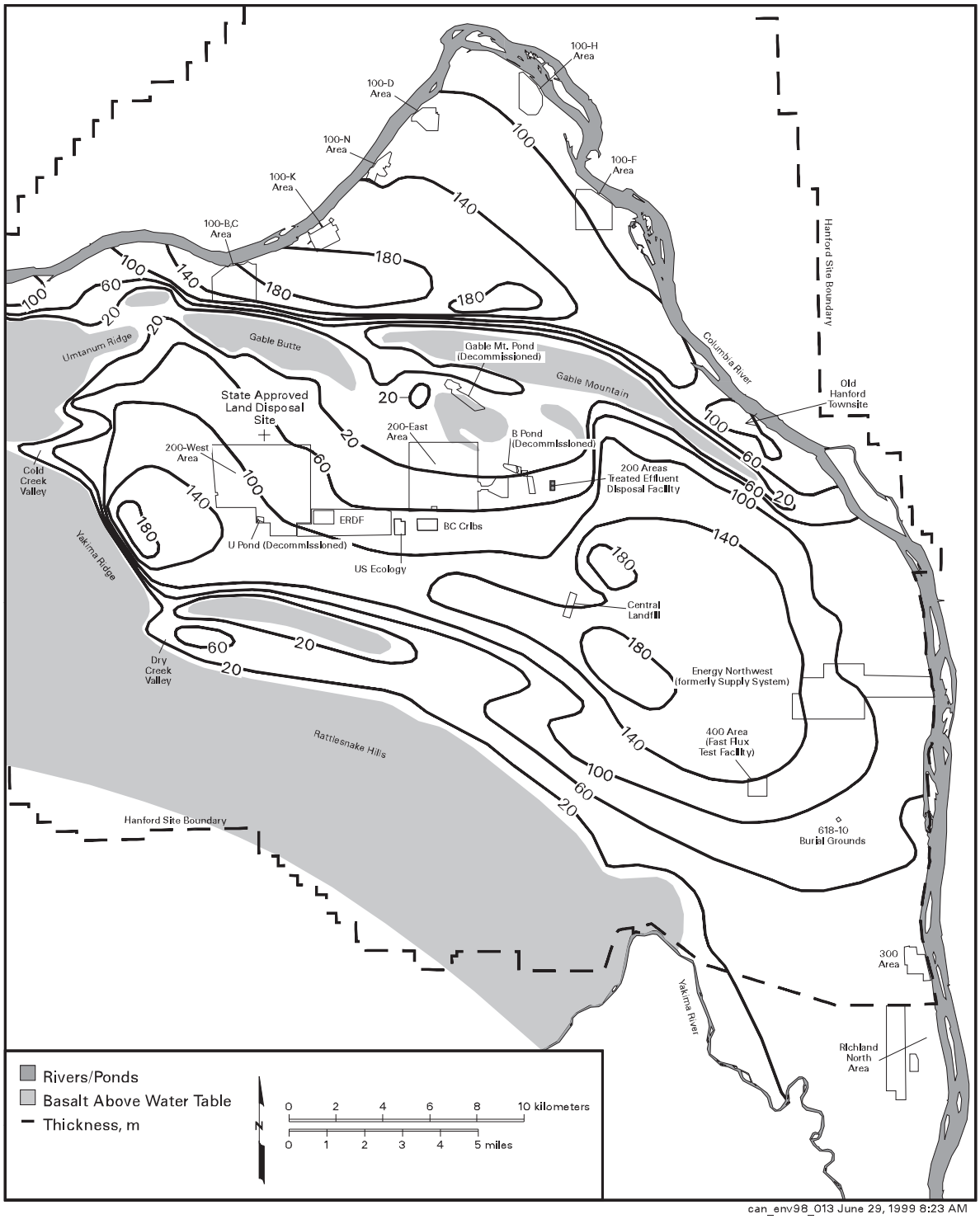


Figure 6.1.4. Saturated Thickness of the Unconfined Aquifer

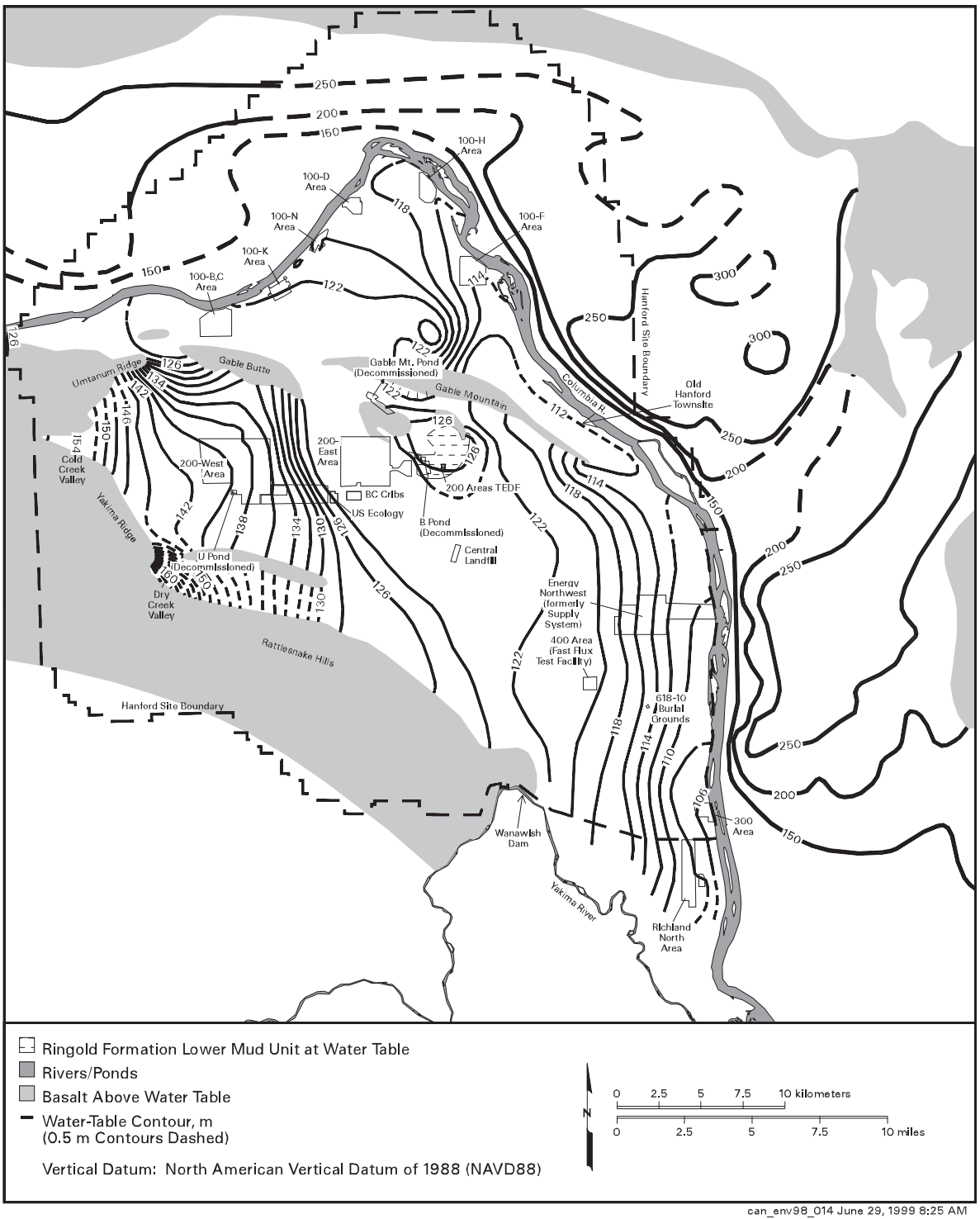


Figure 6.1.5. Water-Table Evaluations for the Unconfined Aquifer at the Hanford Site and in Adjacent Areas East and North of the Columbia River, June 1998

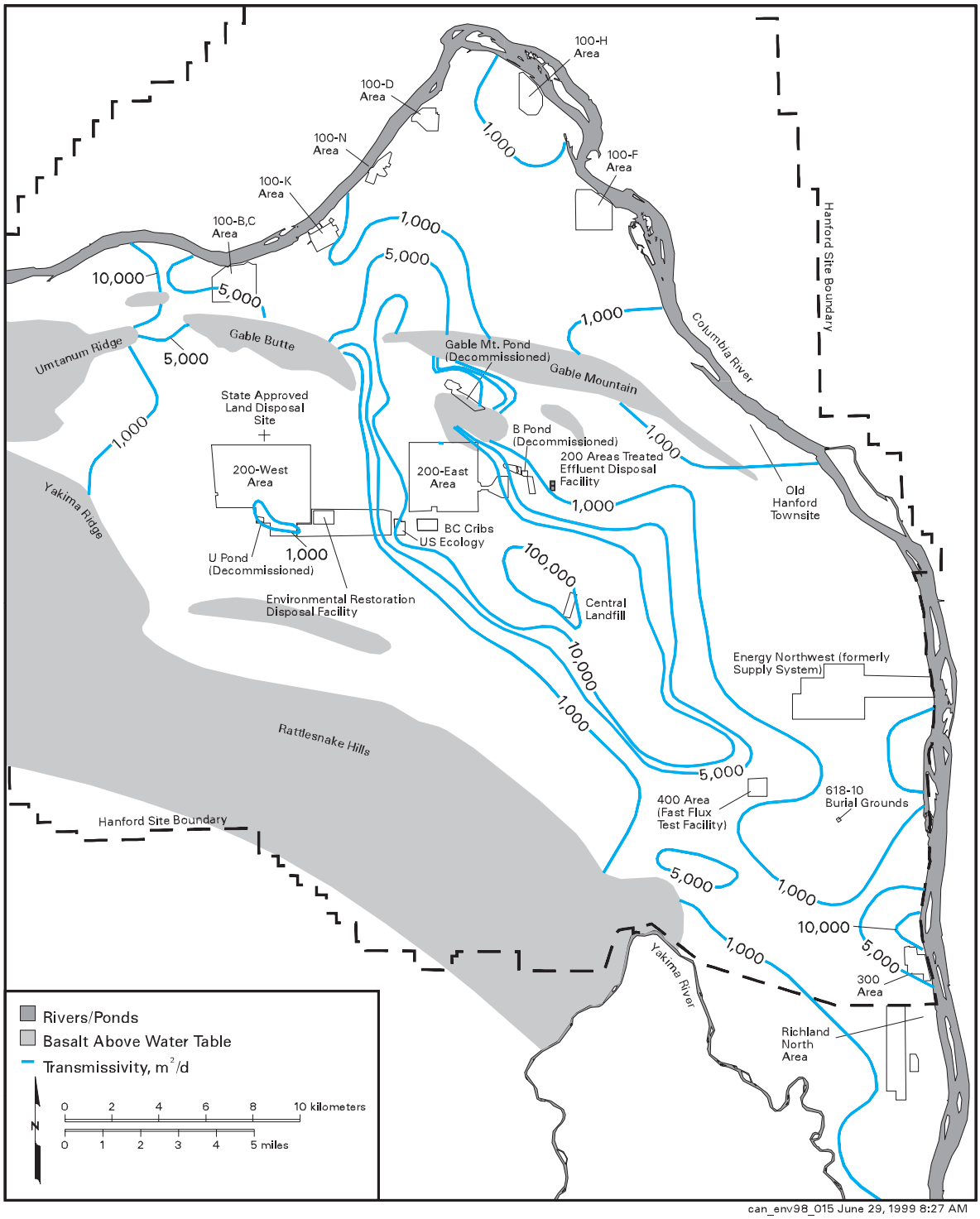


Figure 6.1.6. Transmissivity Distribution in the Unconfined Aquifer

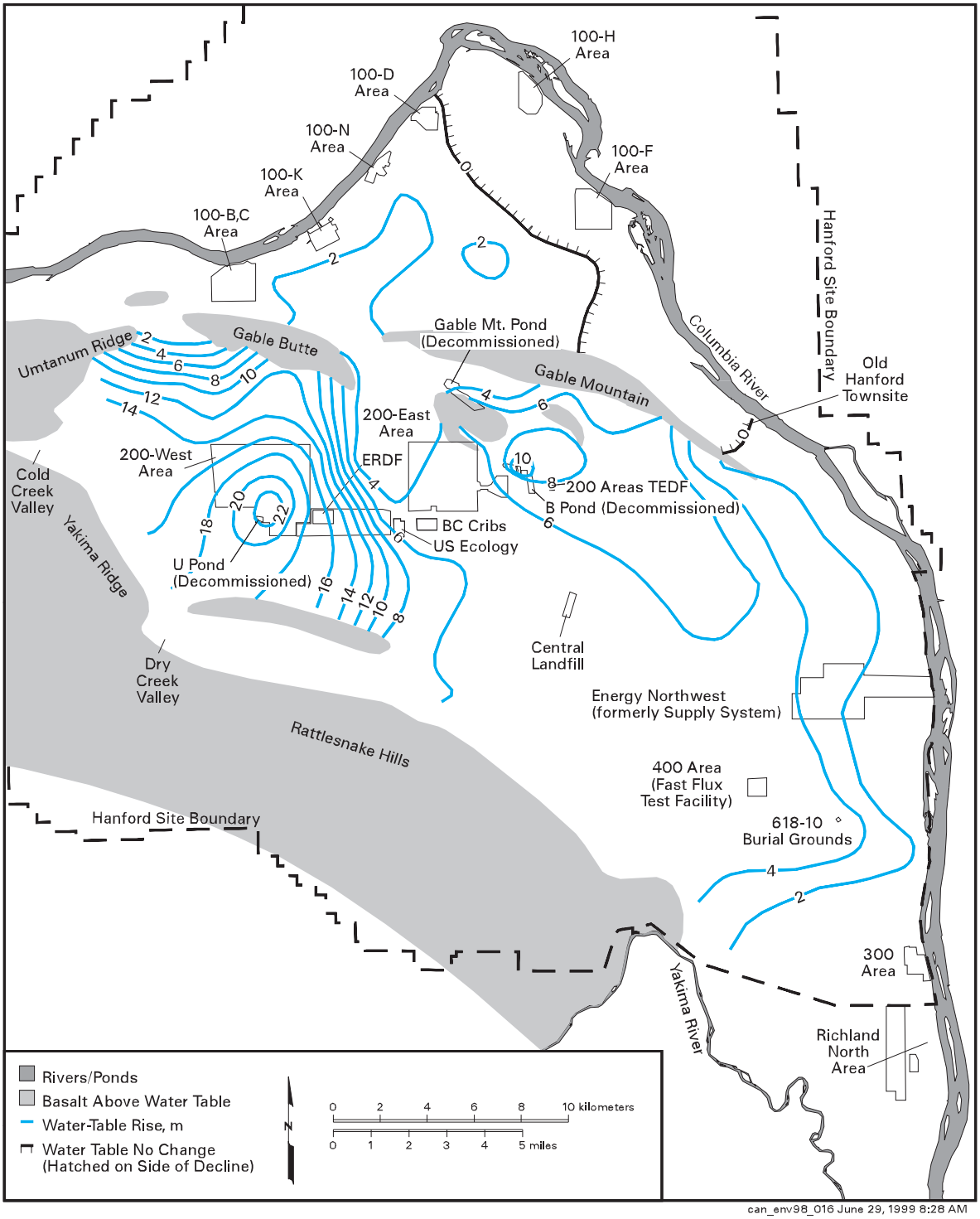


Figure 6.1.7. Change in Water-Table Elevations Between 1949 and 1979

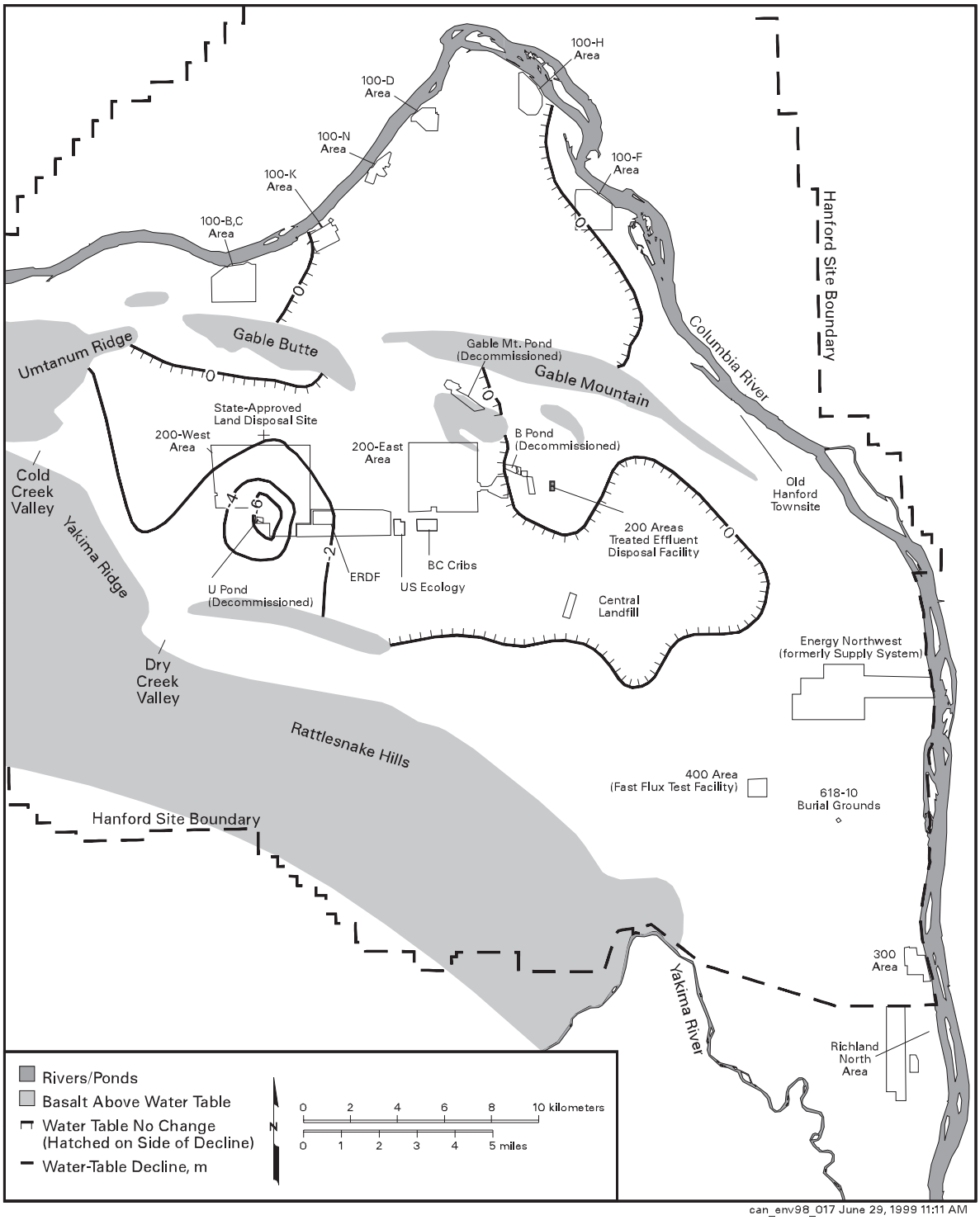


Figure 6.1.8. Change in Water-Table Elevations Between 1979 and 1995

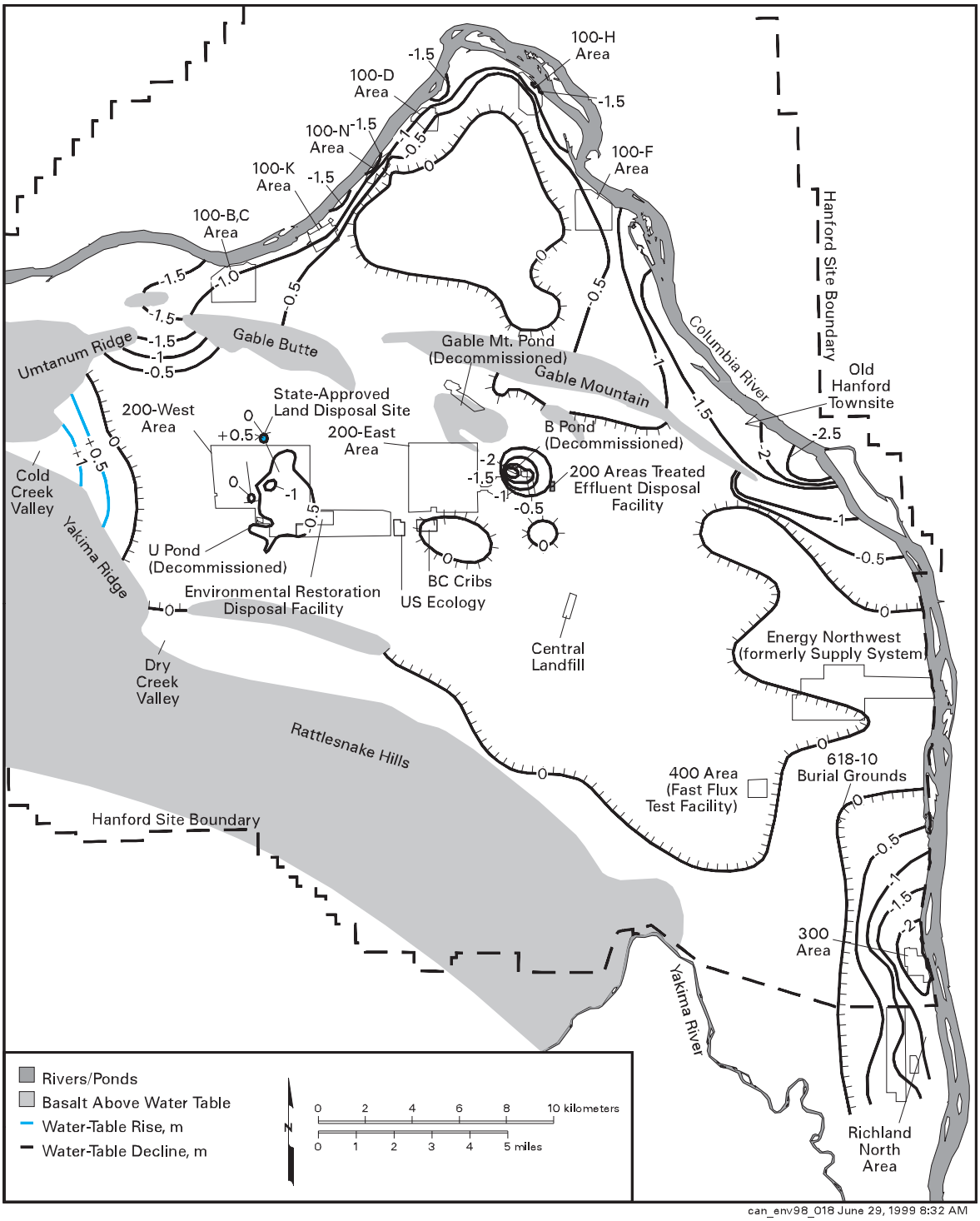


Figure 6.1.9. Change in Water-Table Elevations Between 1997 and 1998

the last several years. The water table continues to decline in this area (see Figure 6.1.9). The second major mound was created by discharge to the decommissioned, or former, 216-B-3 Pond (B Pond), east of the 200-East Area. The water-table elevation near B Pond increased to a maximum before 1990 and then decreased because of reduced discharge. After discharge to B Pond ceased in August 1997, the decline in the water-table elevation accelerated. The recent decline in the water-table elevation at B Pond is illustrated by the contours in Figure 6.1.9. These mounds have altered the unconfined aquifer's natural flow pattern, which is generally from the recharge areas in the west to the discharge areas (primarily the Columbia River) in the east and north. Water levels in the unconfined aquifer have continually changed as a result of variations in the volume and location of wastewater discharge. Consequently, the movement of groundwater and its associated constituents has also changed with time. Groundwater mounding related to wastewater discharges has also occurred in the 100 and 300 Areas; however, groundwater mounding in these areas is not as great as in the 200 Areas primarily because of lower discharge volumes.

In the 100 Areas, 300 Area, and other locations near the Columbia River, groundwater levels are influenced by river stage (PNL-9437). The Columbia River stage returned to normal levels in 1998 after an unusually high-river stage throughout most of 1996 and 1997. This resulted in a lowering of the water table near the river. As a result, water flowed from the aquifer into the river during much of the year.

6.1.3 Contaminant Transport

The history of contaminant releases and the physical and chemical principles of mass transport control the distribution of radionuclides and chemicals in groundwater. Processes that control the movement of these contaminants at the Hanford Site are discussed below.

Most of the groundwater contamination at the Hanford Site resulted from discharge of wastewater from reactor operations, reactor fuel fabrication, and processing of spent reactor fuel. Table 6.1.1 lists the principal contaminants found in each operational area and the type of operation that generated them. In the 100 Areas, discharges included reactor cooling water, fuel storage basin water, filter backwash, and smaller amounts of waste from a variety of other processes. In the 200 Areas, large quantities of wastewater from fuel reprocessing were discharged. Other contamination sources in the 200 Areas included plutonium purification waste and decontamination waste. The plutonium purification process resulted in the discharge of large amounts of liquid organic chemicals in addition to aqueous solutions. This organic liquid, once in contact with groundwater, slowly dissolves and produces contaminant plumes. The presence of nonaqueous liquid has a major impact on the site's groundwater remediation strategy because the organic liquid in the subsurface represents a continuing source of contamination but is very difficult to clean up. Groundwater contamination in the 300 Area resulted mainly from discharge of fuel fabrication wastes.

Liquid effluents discharged to the ground at Hanford Site facilities percolated downward through the unsaturated zone toward the water table. Radionuclide and chemical constituents move through the soil column and, in some cases, enter the groundwater. In some locations, sufficient water was discharged to saturate the soil column to the surface. Not all contaminants move at the same rate as the water in the subsurface. Chemical processes such as adsorption onto soil particles, chemical precipitation, and ion exchange slow the movement of some constituents such as strontium-90, cesium-137, and plutonium-239,240. However, these processes may

Table 6.1.1. Chemical and Radiological Groundwater Contaminants and Their Link to Site Operations

Constituents Generated	Areas	Facilities Type
Tritium, ^{60}Co, ^{90}Sr, Cr^{6}, SO_4^{-2}	100	Reactor operations
Tritium, ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs, Pu, U, CN^{-}, Cr^{6}, F^{-}, NO_3^{-}	200	Irradiated fuel processing
Pu, carbon tetrachloride, chloroform, NO_3^{-}	200	Plutonium purification
^{99}Tc, U, Cr^{6}, trichloroethylene	300	Fuel fabrication

be affected by the chemical characteristics of the waste such as high ionic strength, acidity, or presence of chemical complexants. Other radionuclides, such as technetium-99, iodine-129, and tritium, and chemicals, such as nitrate, are not as readily retained by the soil and move vertically through the soil column at a rate nearly equal to the infiltrating water. When the contaminants reach the water table, their activities/concentrations are reduced by dilution with groundwater. As these dissolved constituents move with the groundwater, many radionuclides and chemicals adhere to sediment particle surfaces (adsorption) or diffuse into the particles (absorption). Radionuclide activities are reduced by radioactive decay.

Outside the source areas (i.e., liquid disposal sites), there is typically little or no downward gradient (driving force or head), so contamination tends to remain in the upper part of the aquifer. In the source areas, where large volumes of wastewater were discharged, a large vertical hydraulic gradient developed that moved contaminants downward in the aquifer. Layers of low-permeability silt and clay within the unconfined aquifer also limit the vertical movement of contaminants. Flow in the unconfined aquifer is generally toward the Columbia River, which acts as a drainage area for the groundwater flow system at Hanford. Contamination that reaches the river is further diluted by river water.

6.1.4 Groundwater Modeling

Numerical modeling of groundwater flow and contaminant transport is performed to simulate future groundwater-flow conditions and predict the migration of contaminants through the groundwater pathway. During 1998, a model was used to support the composite analysis (PNNL-11800) for low-level waste disposal at the Hanford Site. The objective of the composite analysis was to predict the flow of groundwater and transport of radioactive contaminants during a 1,000-yr compliance period following closure of the Hanford Site in the future. The transport simulation was based on radioactive contaminants that were expected to exist on the site in the year 2050, the assumed closure date, and on predicted future groundwater flow conditions. Simulated contaminants included tritium, carbon-14, chlorine-36, selenium-79, technetium-99, iodine-129, uranium, and other radionuclides from waste sites and the vadose zone. Other models were used in the design and evaluation of pump-and-treat activities aimed at remediation of contaminated groundwater in the 200-West Area. A brief description of these modeling efforts is provided here; additional details and results are presented in PNNL-12086 (Section 6.0) and DOE/RL-99-02.

During the past several years, a three-dimensional flow and transport model has been under

development. The objective of developing a three-dimensional model was to provide more accurate simulations of contaminant transport within the sitewide unconfined aquifer system. The model is based on the Coupled Fluid, Energy, and Solute Transport (CFEST) code (BMI/ONWI-660). The model has since been updated to a new version of the CFEST code called CFEST-96, which was used for the composite analysis. The model includes up to nine layers above the top of basalt to represent the major hydrogeologic units within the unconfined aquifer system.

The water table was predicted to decline significantly and return to near pre-Hanford Site groundwater flow conditions over an approximately 300-yr period following site closure. Wastewater discharges to the ground were assumed to be eliminated before site closure. The areas where the future water table was predicted to be different from pre-Hanford conditions include effects of increased offsite irrigation on the western part of the site and effects from the city of Richland's North Well Field recharge ponds near the southern part of the site.

Predicted distributions of contaminants in the unconfined aquifer during the 1,000-yr compliance period are presented in PNNL-11801.

Groundwater models were also used to assess the performance of groundwater pump-and-treat systems in the 200-UP-1 and 200-ZP-1 Operable Units in the 200-West Area. In these systems, contaminated water is removed by means of extraction wells, treated, and either disposed of to the State-Approved Land Disposal Site (200-UP-1) or returned to the aquifer through injection wells (200-ZP-1) (BHI-01126). The models were used to predict system performance and progress toward remediation goals. The modeling was used to evaluate different extraction and injection well configurations, predict effects of pumping, assess the extent of hydraulic influence and the capture zone, and evaluate groundwater travel times. Modeling was conducted using the Micro-FEM© finite-element code developed by C. J. Hemker, Amsterdam, The Netherlands. Groundwater modeling for the 200-UP-1 plume indicated that the area of high technetium-99 activity and uranium concentration was captured using the one extraction well (299-W19-39) (DOE/RL-99-02). Modeling of the 200-ZP-1 pump-and-treat operation predicts that the high-concentration area of the carbon tetrachloride plume will be captured. As of September 1998, measurable progress was made toward hydraulic containment of the high-concentration areas of the plumes at each of these pump-and-treat operations (DOE/RL-99-02).

6.1.5 Groundwater Monitoring

Groundwater monitoring at the Hanford Site is an integral part of the *Hanford Site Ground-Water Protection Management Plan* (DOE/RL-89-12, Rev. 2). That plan integrates monitoring at active waste disposal facilities to comply with requirements of the RCRA and Washington State regulations, as well as requirements for operational monitoring around reactor and chemical processing facilities and environmental surveillance monitoring. Pacific Northwest National Laboratory manages these monitoring efforts to assess the distribution and movement of existing groundwater contamination, to identify potential and emerging groundwater contamination problems, and to integrate the various groundwater projects to minimize redundancy.

The *Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project* (PNNL-11989) describes how the DOE will implement the groundwater monitoring requirements outlined in DOE (1987) and DOE/RL-89-12, Rev. 2. The purpose of the integrated monitoring plan is to 1) describe the monitoring well networks, constituents, sampling frequencies, and criteria used to design the monitoring

program; 2) identify federal and state groundwater monitoring requirements and regulations; and 3) provide a list of wells, constituents, and sampling frequencies for groundwater monitoring conducted on the Hanford Site. Federal and state regulations include RCRA, CERCLA, and Washington Administrative Codes.

Information on contaminant distribution and transport are integrated into a sitewide evaluation of groundwater quality, which is documented in an annual groundwater monitoring report (e.g., PNNL-12086). Groundwater monitoring is also carried out during CERCLA cleanup investigations. These investigations, managed by Bechtel Hanford, Inc., are documented in annual summary reports (e.g., DOE/RL-99-02).

6.1.5.1 Groundwater Sampling and Analytes of Interest

Groundwater samples were collected from 671 wells for all monitoring programs during 1998. The locations of sampled wells are shown in Figures 6.1.10 and 6.1.11; well names are indicated only for those 400 and 600 Area wells specifically discussed in the text. Because of the density of unconfined aquifer wells in the operational areas, well names in these areas are shown on detailed maps in the following sections. Figure 6.1.12 shows the locations of facilities where groundwater monitoring was conducted to comply with RCRA (Appendix A in PNNL-12086). Wells at the Hanford Site generally follow a naming system that indicates the approximate location of the well. The prefix of the well name indicates the area of the site, as shown in Table 6.1.2. The names for 600 Area wells follow a local coordinate system in which the numbers indicate the distance relative to an arbitrary datum location in the south-central part of the site.

The monitoring frequency for the wells is selected based on regulatory requirements, variability of historical data, proximity to waste sources, and characteristics of the groundwater flow system at the sample location. Of the 671 wells sampled, 286 were sampled once, 174 twice, 25 three times, 99 four times, and 87 more than four times during the year. In 1998, the sampling frequency was changed to every 3 yr for several wells that showed concentrations with steady historical trends. Wells showing larger variability are sampled more frequently (annually or more often). Wells that monitor source areas are sampled more frequently than wells that do not monitor source areas. Contaminants with greater mobility (e.g., tritium) may be sampled more frequently than those that are not very mobile in groundwater (e.g., strontium-90).

Each monitoring program has access to groundwater data collected by other programs through a common database, the Hanford Environmental Information System. This database contains >1.5 million groundwater monitoring result records. After the data are verified and/or validated, they are made available to federal and state regulators for retrieval.

Most groundwater monitoring wells on the site are 10 to 20 cm (4 to 8 in.) in diameter. Monitoring wells for the unconfined aquifer are constructed with well screens or perforated casing generally in the upper 3 to 6 m (10 to 20 ft) of the unconfined aquifer, with the open interval extending across the water table. This construction allows sample collection at the top of the aquifer, where maximum activities of radionuclides tend to be found. Wells monitoring the shallowest of the basalt-confined aquifers have screens, perforated casing, or an open hole within the monitored aquifer. Wells drilled before 1985 were generally constructed with carbon steel casing. Since 1985, RCRA monitoring wells and CERCLA characterization wells have been constructed with stainless steel casing and screens. Most monitoring wells on the site are sampled using either submersible or Hydrostar™ pumps (a registered trademark of Instrumentation Northwest, Inc., Redmond, Washington), though some wells are sampled with bailers or airlift systems.

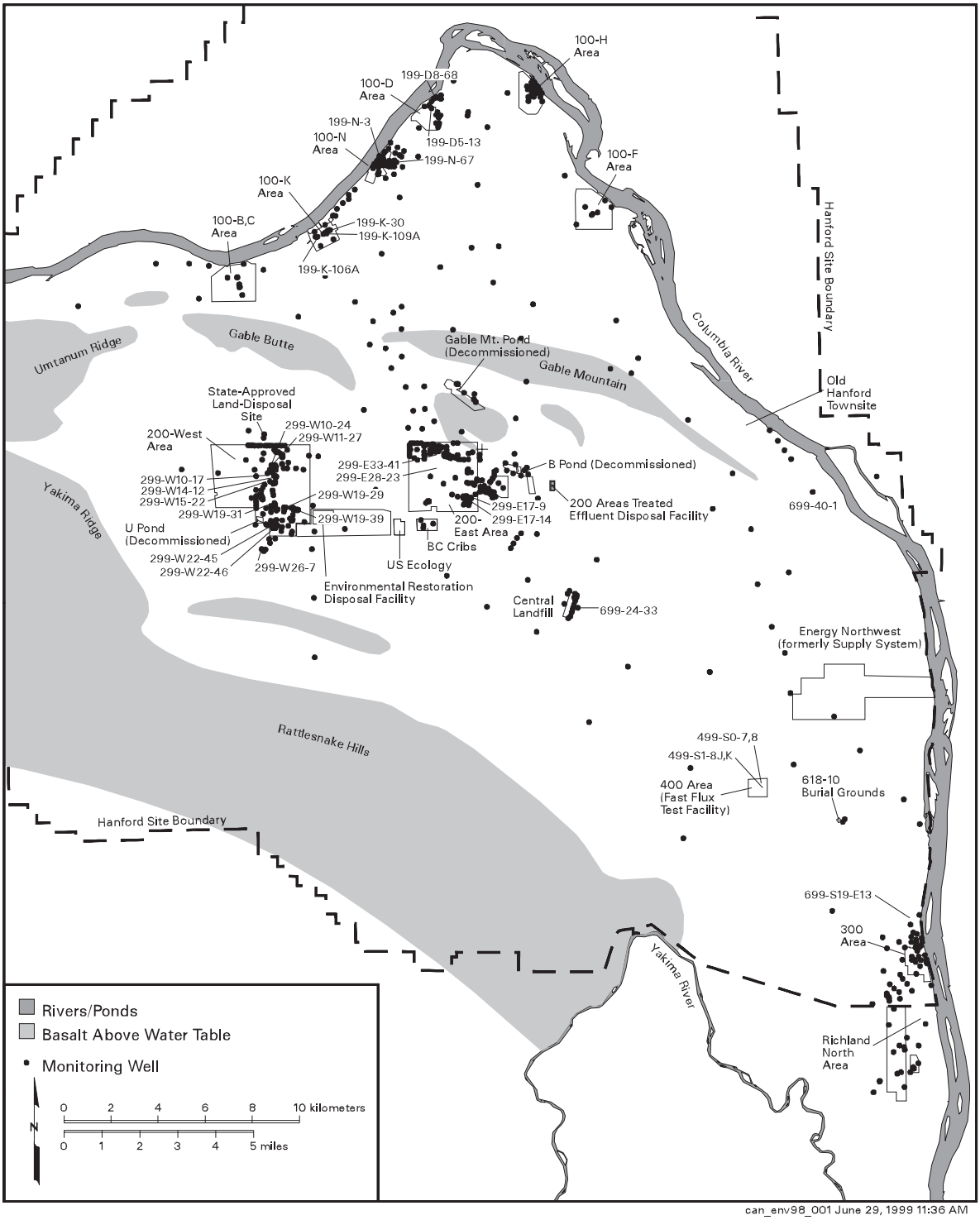


Figure 6.1.10. Unconfined Aquifer Monitoring Well Locations, 1998

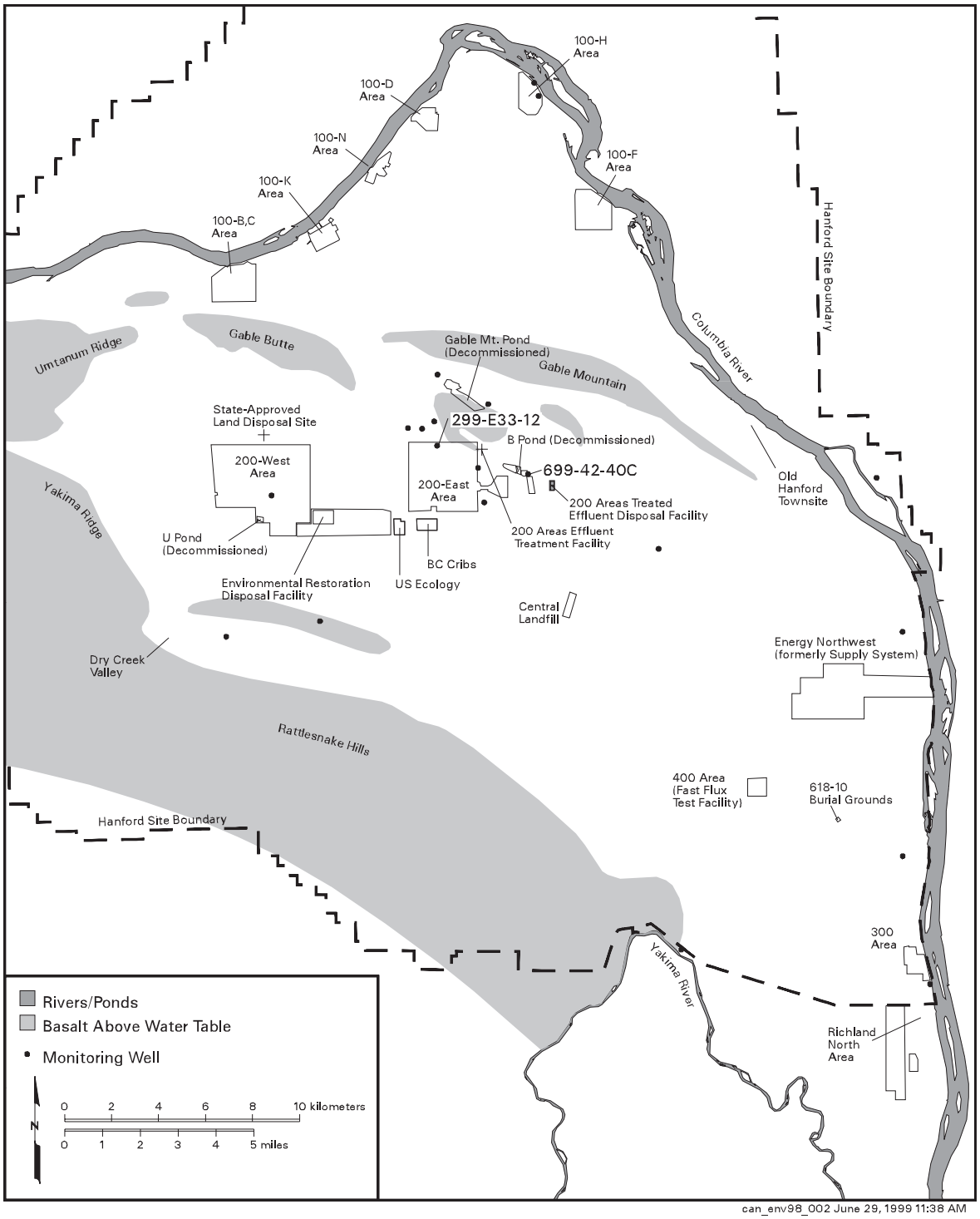
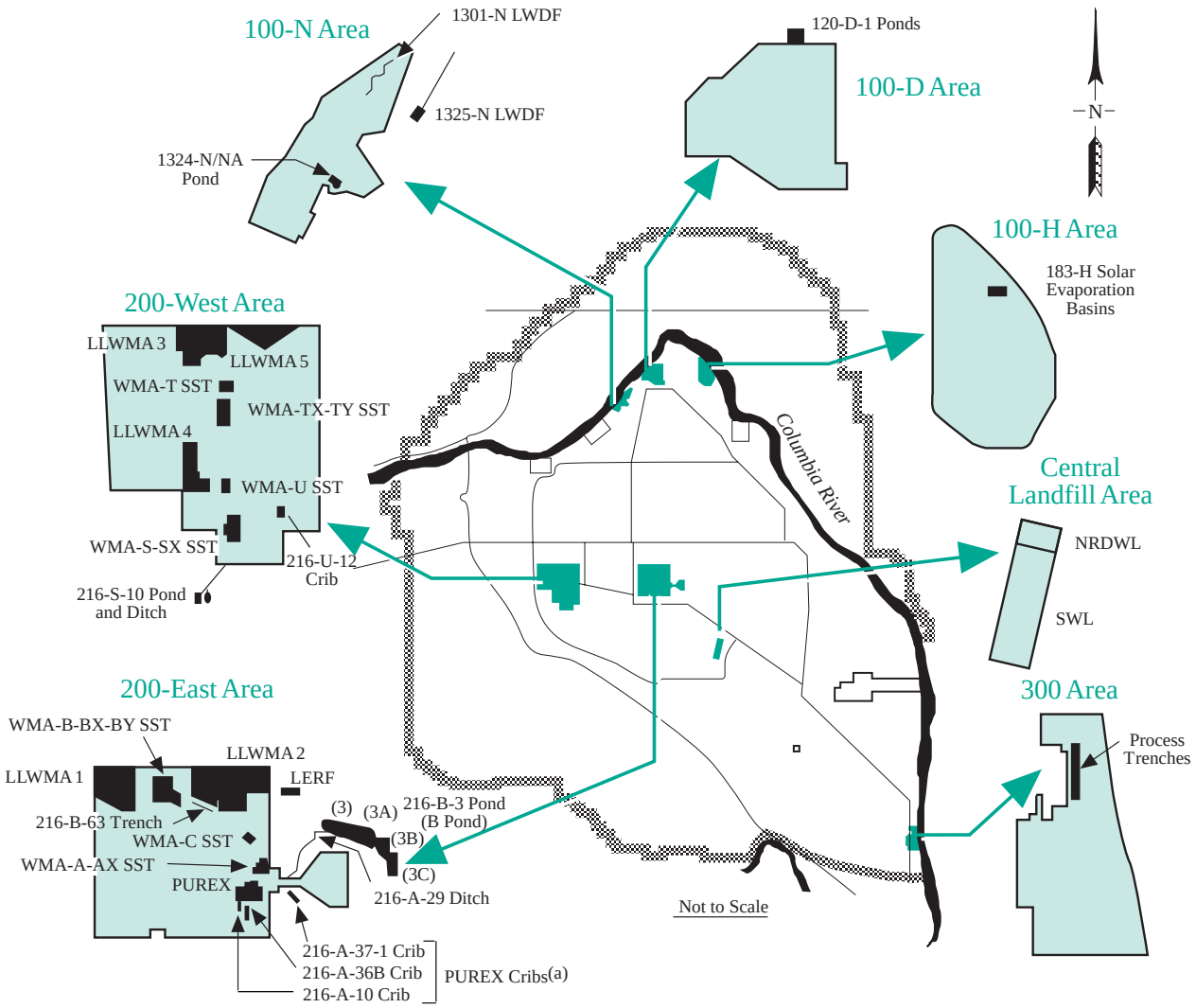


Figure 6.1.11. Confined Aquifer Monitoring Well Locations, 1998



LERF	Liquid Effluent Retention Facility	PUREX	Plutonium-Uranium Extraction (Plant)
LLWMA	Low-Level Waste Management Area	SST	Single-Shell Tank
LWDF	Liquid Waste Disposal Facility	SWL	Solid Waste Landfill
NRDWL	Nonradioactive Dangerous Waste Landfill	WMA	Waste Management Area

G99030045.94

(a) PUREX cribs are one RCRA groundwater monitoring project

Figure 6.1.12. Locations of RCRA Groundwater Monitoring Projects

Table 6.1.2. Hanford Site Well Naming System

Example Well Name	Area
199-	**100 Areas**
199-B3-47	100-B,C Area
199-D5-12	100-D Area
199-F8-3	100-F Area
199-H4-3	100-H Area
199-K-30	100-K Area
199-N-67	100-N Area
299-	**200 Areas**
299-W19-3	200-West Area
299-E28-4	200-East Area
399-	**300 Area**
399-1-17A	300 Area
499-	**400 Area**
499-S1-8J	400 Area
699-	**600 Area**
699-50-53A	600 Area north and west of datum
699-42-E9A	600 Area north and east of datum
699-S19-11	600 Area south and west of datum
699-S19-E13	600 Area south and east of datum

Note: Letters at end of well names distinguish either multiple wells located close together or multiple intervals within a single well bore.

Samples were collected for all programs following documented sampling procedures (PNL-6894, Rev. 1; ES-SSPM-001) based on U.S. Environmental Protection Agency (EPA) guidelines (OSWER 9950-1). Analytical techniques used are listed in DOE/RL-91-50, Rev. 2; PNL-10698 (Section 4.1.7); and CERCLA work plans. The radionuclides and chemicals analyzed for are listed in Table 6.1.3.

Most groundwater samples collected on the site in 1998 were analyzed for tritium. Selected samples were analyzed for other radionuclides. Sample results for radionuclides are generally presented in picocuries per liter; however, the results for total uranium, which is usually measured by laser fluorescence, are given in micrograms per liter.

Nitrate analyses were performed on many samples collected during 1998 because of the extensive areas with elevated nitrate concentrations that originate from onsite and offsite sources. However, nitrate concentrations were below the EPA 45-mg/L drinking water standard (40 CFR 141) for most of the affected area. Selected monitoring wells were used for additional chemical surveillance.

6.1.5.2 Data Interpretation

Each analysis of a groundwater sample provides information on the composition of groundwater at one time at one location in the aquifer. Uncertainty in the analyses results from a number of sources. Some of the sources of uncertainty are discussed below. Several techniques used to interpret the sample results are also discussed.

Groundwater sampling techniques are designed to collect a sample that is representative of the constituent concentration in the aquifer when the sample is taken. However, there are limitations in collecting representative samples or even defining precisely the volume of the aquifer represented by the sample. Proper well construction and maintenance, well purging, sample preservation, and, in some instances, filtering are used to help ensure consistent and representative samples. Careful sample labeling protocols, chain-of-custody documentation, and bottle preparation avoid many gross errors in sample results. Duplicate samples and field blanks are used to assess the sampling procedure.

Uncertainties are inherent in laboratory analysis of samples. Gross errors can be introduced in the laboratory or during sampling. Gross errors include transcription errors, calculation errors, mislabeling results, field equipment problems, or other errors that result from not following established procedures.

Table 6.1.3. Radionuclides and Chemicals Analyzed for in Groundwater, 1998

Radiological Parameters	Chemical Parameters
Tritium	pH (field and laboratory)
Beryllium-7	Conductance (field and laboratory)
Carbon-14	Total dissolved solids
Potassium-40	Alkalinity
Cobalt-58	Total carbon
Iron-59	Total organic carbon
Cobalt-60	Total organic halogens
Strontium-90	B, Be, Na, Mg, Al, K, Co, Si, As, Se
Technetium-99	Ca, V, Cr, Mn, Fe, Ni, Pb, Li, Hg
Ruthenium-106	Cu, Zn, Sr, Ag, Cd, Sb, Ba, Sn, Tl, Ti
Antimony-125	F^-, Cl^-, NO_3^-, PO_4^{-3}, SO_4^{-2}, NO_2^-, Br^-
Iodine-129	CN^-
Cesium-134	NH_4^+
Cesium-137	Hexavalent chromium
Neptunium-237	Volatile organic compounds
Americium-241	Semivolatile organic compounds
Gross alpha	Polychlorinated biphenyls
Gross beta	Pesticides/herbicides
Europium isotopes	Chemical oxygen demand
Plutonium isotopes	Dissolved oxygen
Radium isotopes	Total petroleum hydrocarbons
Uranium isotopes	Oil and grease
Uranium (total)	Diesel oil
	Gasoline

Often, these gross errors can be recognized because unreasonably high or unreasonably low values result. Data review protocols are used to investigate and correct gross errors.

Random errors are unavoidably introduced in the analytical procedures. Usually, there are insufficient replicate analyses to assess the overall random error at each sample location. Instruments for analysis of radioactive constituents count the number of radioactive decay products at a detector, and background counts are subtracted. The nature of radioactive decay and the instrument design result in a random counting error that is reported with the analytical result. Generally, a sample result less than the counting error indicates the constituent was not detected. The background subtraction may result in the reporting of results that are less than zero. Although below-zero results are physically impossible, the negative values are of use for some statistical analyses (see "Helpful Information" section for more details).

Systematic errors may result from problems with instrument calibration, standard or sample preparation, chemical interferences in analytical techniques, as well as sampling methodology and sample handling. Sample and laboratory protocols have been designed to minimize systematic errors. The analytical laboratories participate in interlaboratory comparisons, in which many laboratories analyze blind samples prepared by the EPA (see Section 8.0, "Quality Assurance").

In 1998, double-blind samples for specific constituents were analyzed (Section 8.0, "Quality Assurance," discusses double-blind results). Several wells were also cosampled with the Washington State Department of Health for comparison, and the results are available from that agency.

The chemical composition of groundwater may fluctuate from differences in the contaminant source, recharge, or groundwater flow field. The range of this concentration fluctuation can be estimated by taking many samples, but there is a limit to the number that can be practicably taken. Comparison of results through time helps interpret this variability.

Overall sample uncertainty may be factored into data evaluation by considering the concentration trend in a given well over time. This often helps identify gross errors, and overall, long-term trends can be distinguished from short-term variability. The interpretation of concentration trends depends on an understanding of chemical properties as well as site hydrogeology. The trend analysis, in turn, aids in refining the conceptual model of the chemical transport.

Plume maps presented in this section illustrate site groundwater chemistry. Although analytical data are available only at specific points where wells were sampled, contours are drawn to join the approximate locations of equal chemical concentration or radionuclide activity levels. The contour maps are simplified representations of plume geometry because of map scale, the lack of detailed information, and the fact that plume depth and thickness cannot be fully represented on a two-dimensional map. Plume maps are a powerful tool because knowledge of concentrations in surrounding wells, groundwater flow, site geology, and other available information are factored into their preparation.

6.1.6 Groundwater Monitoring Results

The following sections summarize the distribution of radioactive and chemical contaminants detected in Hanford Site groundwater during 1998. These discussions are followed by a summary of groundwater monitoring results for RCRA sites. More detailed information on groundwater monitoring, including listings of analysis results for each monitoring well in electronic format, is available in PNNL-12086. However, because PNNL-12086 (the annual groundwater report) covers the fiscal year, it does not include results from the last 3 mo of 1998.

One way to assess the impact of radionuclides and chemicals in groundwater is to compare them to EPA's drinking water standards and DOE's derived concentration guides (40 CFR 141 and DOE Order 5400.5; see Appendix C, Tables C.2 and C.5). The drinking water standards are for protecting public drinking water supplies. The derived concentration guides are for protecting the public from radionuclides resulting from DOE activities. Specific drinking water standards have been promulgated for only a few radiological constituents. Drinking water standards resulting in an annual dose of 4 mrem/yr have been calculated for other radionuclides by considering its half-life, the energy and nature of the radioactive decay, and the physiological factors such as its buildup in particular organs. Drinking water standards are more restrictive than derived concentration guides because the standards are based on an

annual dose to the affected organ of 4 mrem/yr, while the guides are based on an effective dose equivalent of 100 mrem/yr (see Appendix C, Tables C.2 and C.5). In addition, the standards use older factors for calculating the concentrations that would produce a 4-mrem/yr dose than are used in calculating the guides. Thus, the values used below for standards are not always in agreement with the guides, which are available only for radionuclides. Primary and secondary drinking water standards are given for some chemical constituents; secondary standards are based on aesthetic rather than health considerations.

6.1.6.1 Radiological Monitoring Results for the Unconfined Aquifer

The radionuclides for which analyses were conducted on Hanford Site groundwater were listed in Table 6.1.3. The distribution of tritium, iodine-129, technetium-99, uranium, strontium-90, carbon-14, cesium-137, cobalt-60, and plutonium are discussed in the following sections. Tritium and iodine-129 are the most widespread contaminants associated with past site operations. Technetium-99 and uranium plumes are extensive in the 200 Areas and adjacent 600 Area. Strontium-90 plumes exhibit very high concentrations in the 100 Areas but are of relatively smaller extent. A carbon-14 plume is widely distributed in the 100-K Area. Cesium-137, cobalt-60, and plutonium contamination occurs in isolated areas in the 200 Areas. Gross alpha and gross beta are used as indicators of radionuclide distribution and are not discussed in detail because the specific radionuclides contributing to these measurements are discussed individually. Several other radionuclides, including ruthenium-106, antimony-125, and americium-241, are associated with wastes from Hanford Site operations. Because of their very low activities in groundwater, they are not discussed in this section. Half-lives of the radionuclides are presented in Table H.5 in the "Helpful Information" section.

Tritium. Tritium is present in irradiated nuclear fuel and was released in process condensates associated with decladding and dissolution of the fuel. Tritium was also manufactured as part of the Hanford mission by irradiating targets containing lithium in several reactors from 1949 to 1952 (DOE/EIS-0119F, WHC-SD-EN-RPT-004). In the late 1960s, tritium production took place in N Reactor (WHC-MR-0388).

Tritium was present in many historical waste streams at the Hanford Site and is highly mobile, essentially moving at the same velocity as the groundwater. As a result, the extent of groundwater contamination from site operations is generally reflected by tritium distribution. For this reason, tritium is the radionuclide most frequently monitored for at the Hanford Site. Figure 6.1.13 shows the 1998 distribution of tritium in the unconfined aquifer. Tritium is one of the most widespread contaminants in groundwater across the Hanford Site and exceeded the 20,000-pCi/L drinking water standard in the 100, 200, 400, and 600 Areas. Tritium levels exceeded the 2,000,000-pCi/L derived concentration guide in the 100-K and 200 Areas. Tritium levels are expected to decrease because of dispersion and radioactive decay (half-life is 12.35 yr).

In 1998, the only tritium bearing liquid effluent discharged to the soil column on the Hanford Site occurred at the State-Approved Land Disposal Site, which began operating in 1995 and is located just north of the 200-West Area. The total radioactivity received by this facility in 1998 was 31.5 Ci.

Tritium in the 100 Areas. Tritium activities greater than the drinking water standard were detected in the 100-B,C, 100-D, 100-F, 100-K, and 100-N Areas. Tritium was detected above the derived concentration guide in the 100-K Area. The largest tritium plume in the 100 Areas with activities above the drinking water standard occurs along the Columbia River from the 100-N Area to the 100-D Area.

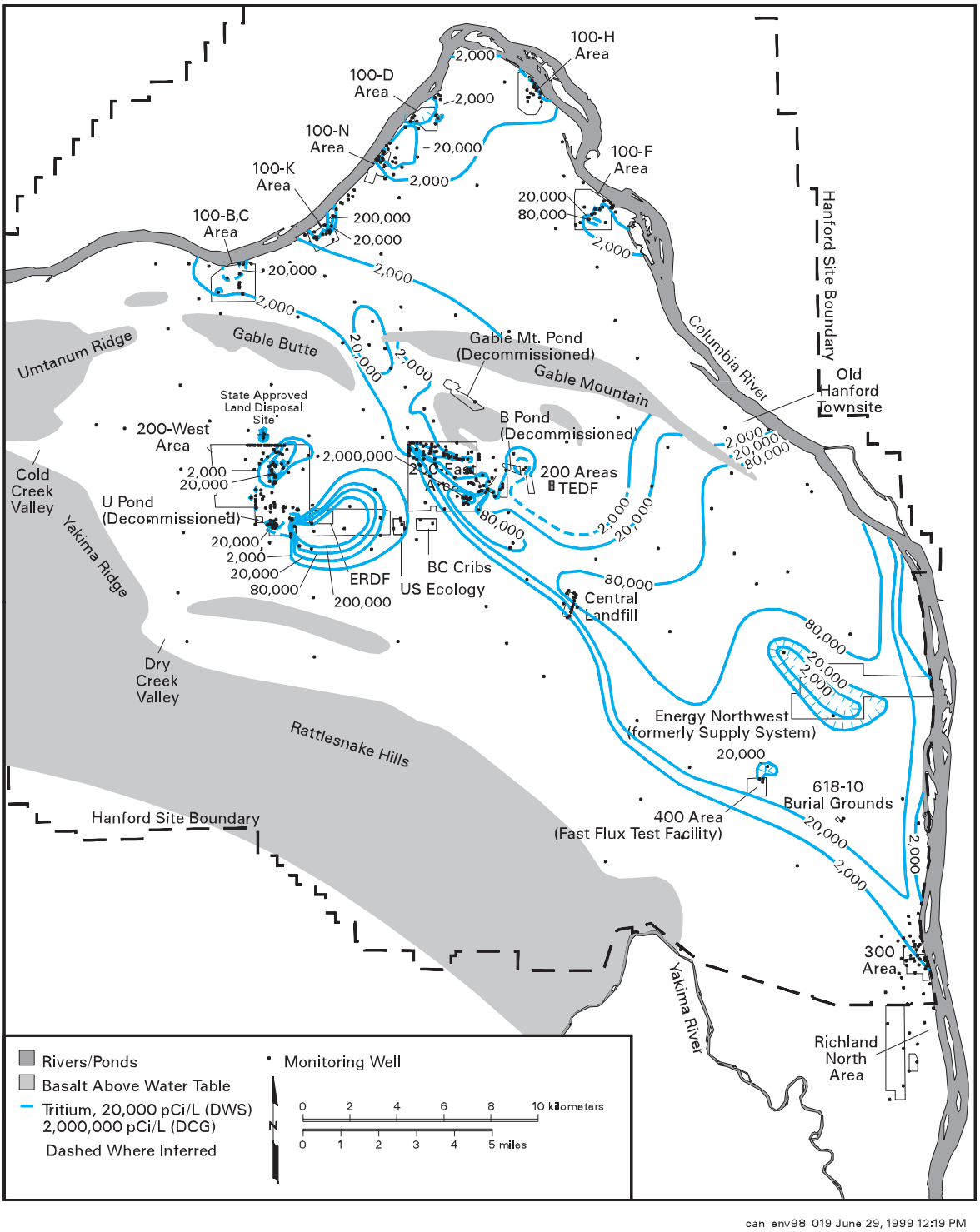


Figure 6.1.13. Average Tritium Activities in the Unconfined Aquifer, 1998

Tritium activities increased to levels above the drinking water standard in several wells in the northern and southwestern parts of the 100-B,C Area in 1998. Most of these are associated with past liquid disposal practices at the 116-B-11 and 116-C-5 Retention Basins and the 116-B-1 and 116-C-1 Trenches near the Columbia River. The maximum tritium activity was 91,900 pCi/L in the southwestern part of the 100-B,C Area. The maximum in the northern part of the 100-B,C Area was 88,100 pCi/L adjacent to the 116-B-11 Retention Basin.

In the 100-D Area, tritium activities were greater than the drinking water standard in the southwestern corner of the area and near D Reactor. The maximum tritium reported during 1998 was 47,000 pCi/L in the southwestern corner of the area and is associated with the tritium plume that extends southwest to the 100-N Area. High activities near D Reactor are associated with past liquid waste disposal to 100-D Area trenches.

One well in the 100-F Area contained tritium at activities greater than the drinking water standard. A maximum of 38,500 pCi/L occurred near the 118-F-1 Burial Ground in 1998. This burial ground received only solid waste, and the source of the tritium contamination is not known.

Well 199-K-30, located near the KE Reactor in the 100-K Area, continued to contain the highest tritium within the 100 Areas, with a maximum activity of 2,360,000 pCi/L. This is the only tritium activity in the 100 Areas that exceeded the derived concentration guide in 1998. The tritium trend for well 199-K-30 is shown in Figure 6.1.14. The probable source is past disposal to a French drain east of the reactor building (DOE/EIS-0119F). The tritium plume with levels greater than the drinking water standard extends downgradient at least 900 m (3,000 ft) from the KE Reactor toward the Columbia River.

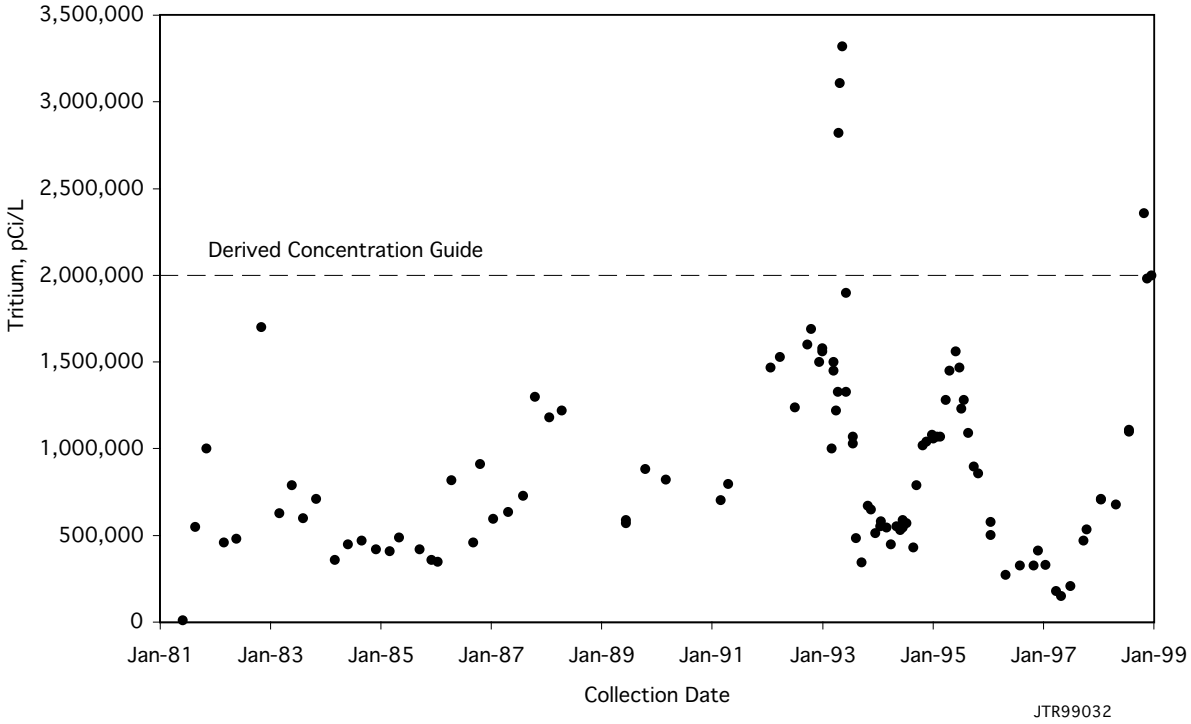


Figure 6.1.14. Tritium Activities in Well 199-K-30, 1982 Through 1998

Tritium in the northern part of the 100-N Area is found at levels greater than the drinking water standard. The tritium plume in this area extends northeast to the 600 and 100-D Areas. This plume is associated with past liquid disposal to the 1301-N and 1325-N Liquid Waste Disposal Facilities. The highest activities, which have decreased in recent years, continued to decrease in 1998. The maximum tritium level reported in the 100-N Area in 1998 was 59,700 pCi/L between the 1301-N facility and the Columbia River.

Tritium in the 200-East and 600 Areas. The highest tritium activities in the 200-East Area continued to be measured in wells near cribs that received effluent from the Plutonium-Uranium Extraction Plant. However, tritium levels are generally decreasing slowly in this area. Levels greater than the derived concentration guide were detected in only one well (299-E17-9) in 1998 in the 200-East Area. The maximum tritium level detected in this well, which monitors the 216-A-36B Crib in the southeastern part of the 200-East Area, was 3,870,000 pCi/L. This was the highest tritium level detected in any well on the Hanford Site.

In the plume that extends from the southeastern portion of the 200-East Area, tritium activities >200,000 pCi/L occurred in a small area downgradient of the Plutonium-Uranium Extraction Plant and did not extend beyond the 200-East Area boundary. These levels were generally lower in 1998 than in previous years as a result of dispersion and radioactive decay. The plume area at levels >200,000 pCi/L has extended at least as far southeast as the Central Landfill in the recent past (PNL-8073).

The movement of the widespread tritium plume (see Figure 6.1.13), extending from the southeastern portion of the 200-East Area to the Columbia River, was consistent with patterns noted in recent monitoring reports (Section 6.1.6.1 in PNNL-11795, Section 5.10.3.2 in PNNL-12086). Separate tritium pulses associated with the two episodes of Plutonium-Uranium Extraction Plant operations can be distinguished in the plume. High-tritium activities east of the 200-East Area near the Columbia River result from discharges to the ground during the operation of the Plutonium-Uranium Extraction Plant from 1956 to 1972. Following an 11-yr shutdown, plant operation began in 1983 and ceased in December 1988. This resulted in elevated tritium levels measured in several wells downgradient from the 200-East Area. Movement of the leading edge of this second pulse is clearly observable near the Central Landfill (Figure 6.1.15), which shows arrival in early 1987. Tritium activities from the first pulse were much higher than from the second. The effects of the second operational period have not been detected near the Columbia River. A trend plot (Figure 6.1.16) of the tritium activities in well 699-40-1 near the shore of the Columbia River shows the arrival of the first pulse in the mid-1970s, but shows no indication that the second pulse has yet arrived.

The tritium plume has been monitored since the 1960s and provides information on the extent of groundwater contamination over time. Figure 6.1.17 shows the distribution of tritium in selected years from 1964 through 1988. This figure was created from maps in BNWL-90, BNWL-1970, PNL-5041, and PNL-6825 (Section 5.0). The contours in the original references were recalculated and interpreted to provide uniform contour intervals. Figure 6.1.17 shows that tritium at levels greater than the drinking water standard reached the Columbia River in approximately the mid-1970s.

The configuration of the western portion of the tritium plume shown in Figure 6.1.13 closely matches previous predictions of the direction of contaminant movement from the 200-East Area (PNL-6328). Movement is forced to the south by the flow that originates at the groundwater mound beneath the former B Pond. Flow to the southeast also appears to be controlled by a zone of highly permeable sediments, stretching from the 200-East Area toward the 400 Area (PNL-7144).

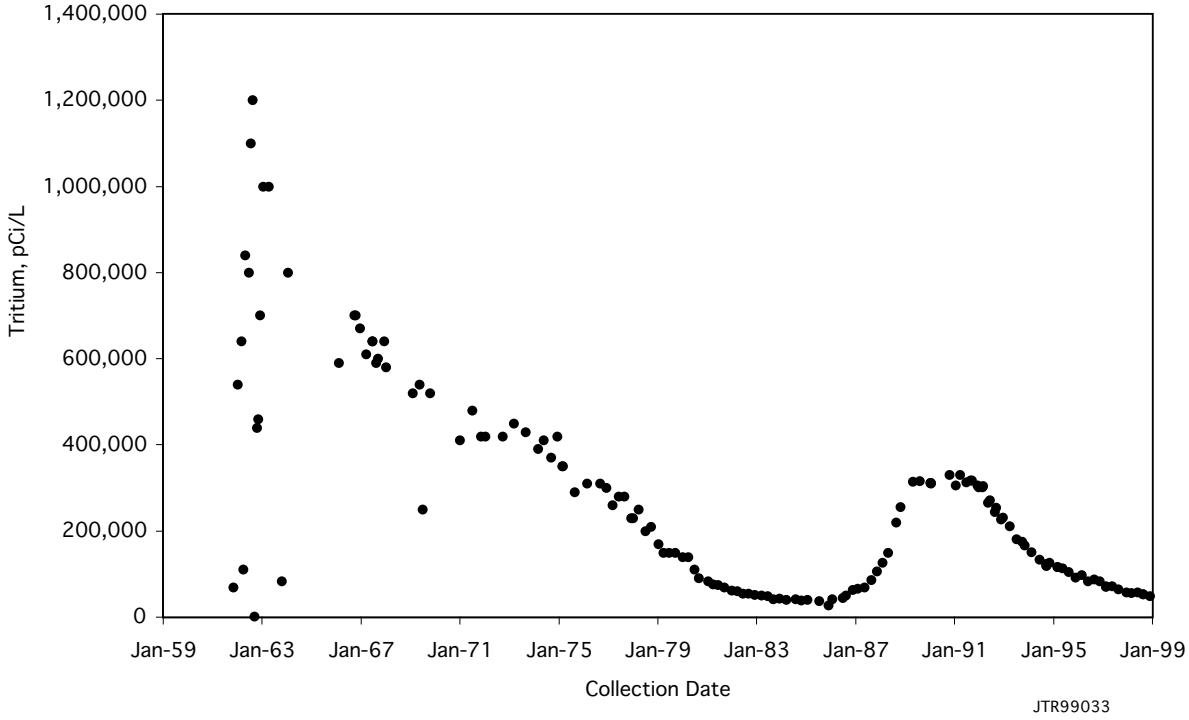


Figure 6.1.15. Tritium Activities in Well 699-24-33, 1962 Through 1998

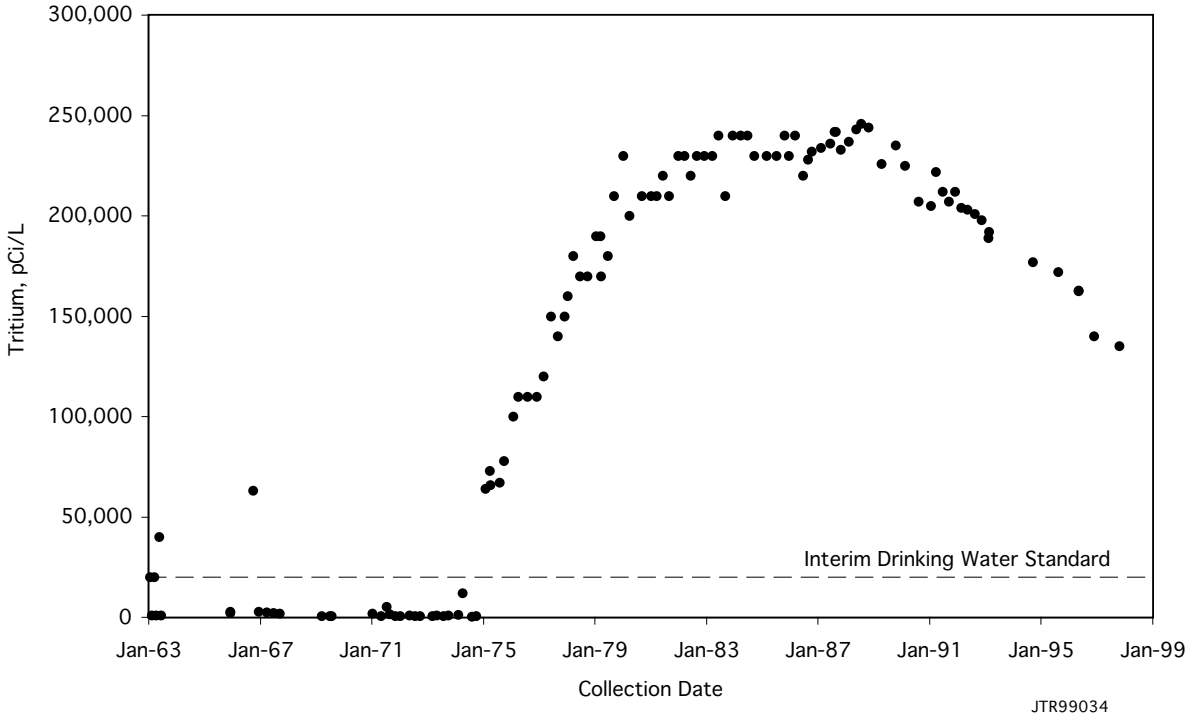


Figure 6.1.16. Tritium Activities in Well 699-40-1, 1963 Through 1998

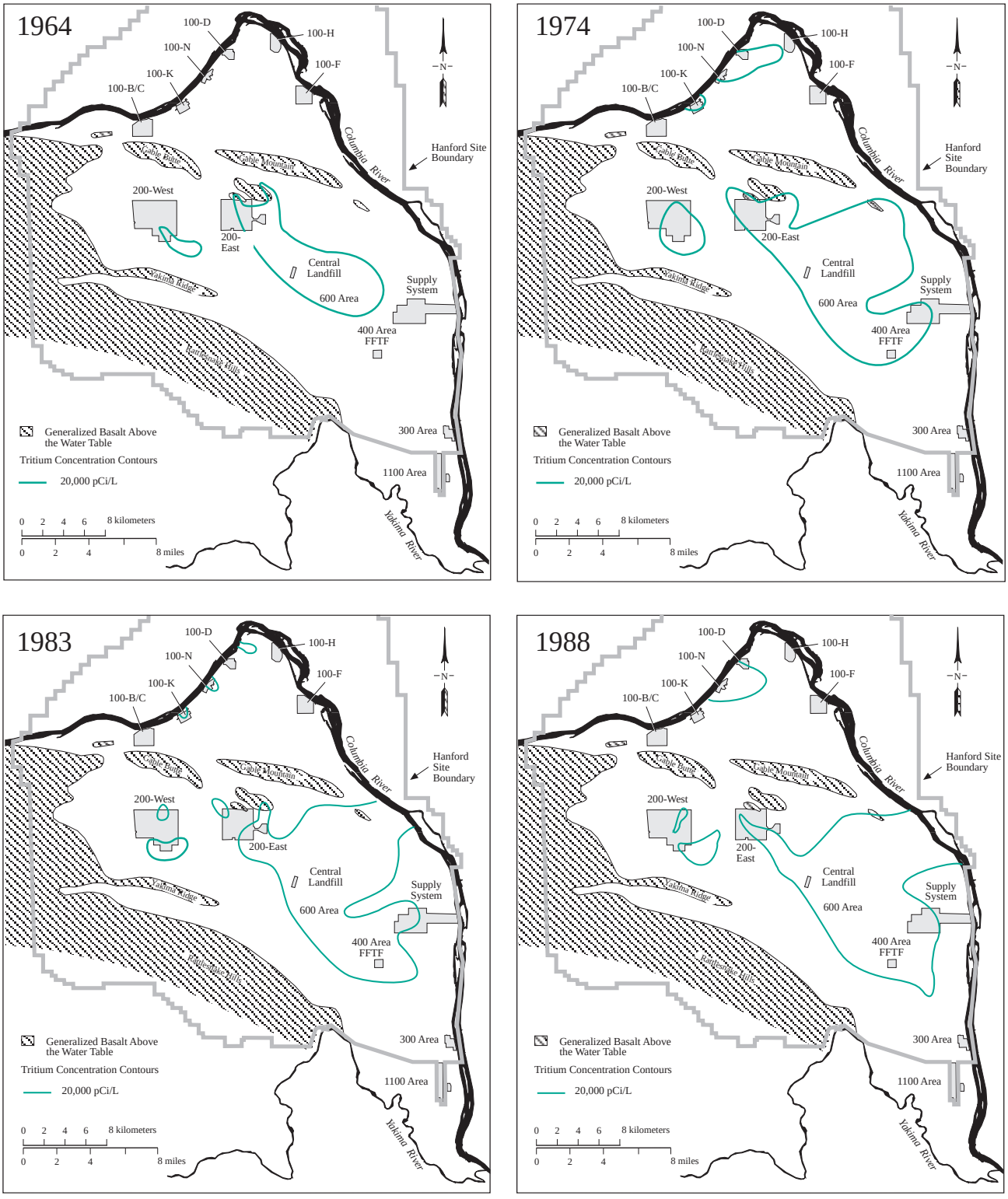


Figure 6.1.17. Historical Tritium Activities on the Hanford Site

The distribution of tritium near the former B Pond shows an area of activity above the drinking water standard in a limited area near the former B Pond. B Pond produced a radial flow pattern of groundwater that mostly had low contaminant levels. The mound under the former B Pond has begun to dissipate since wastewater flow was diverted to the 200 Areas Treated Effluent Disposal Facility in August 1997.

Tritium is also found at levels above the drinking water standard in the northwestern part of the 200-East Area (see Figure 6.1.13). This plume appears to extend to the northwest through the gap between Gable Mountain and Gable Butte. The tritium distribution to the northwest and southeast of the 200-East Area indicates a divide in groundwater flow direction across the 200-East Area. A pulse of tritium levels above the standard also occurred between Gable Mountain and Gable Butte.

Tritium in the 200-West Area. Tritium from sources near the Reduction-Oxidation Plant forms the most extensive plume in the 200-West Area. The Reduction-Oxidation Plant is located in the southeastern part of the 200-West Area and operated from 1951 through 1967. This plume extends into the 600 Area east of the 200-West Area to US Ecology's facility. The eastern part of the plume curves to the north, but the tritium activities in the northern part of the plume are declining. However, activities continue to increase slowly in the eastern part of the plume near the US Ecology facility. Tritium activities exceeded the drinking water standard in much of the plume, including a small area near the former 216-S-25 Crib upgradient of the Reduction-Oxidation Plant. The maximum activity in this plume in 1998 was 451,000 pCi/L in the 600 Area east of the Reduction-Oxidation Plant. The movement of groundwater in the 200-West Area is slow because Ringold Formation sediments have low permeability. Movement of the plumes in the 200-West Area is also slow as a result of declining hydraulic gradients since the closure of U Pond in 1984.

A smaller tritium plume that covers much of the northern part of the 200-West Area occurs in the vicinity of the TX and TY Tank Farms (see Figures 6.1.12 and 6.1.13) and T Plant disposal facilities, which received liquid waste from historical T Plant operations. The highest tritium activity was 3,210,000 pCi/L detected near the TX and TY Tank Farms. This was a sharp increase from 1997 levels and was the only activity that exceeded the derived concentration guide in the 200-West Area in 1998. The area where the drinking water standard was exceeded extends northeast past the northern boundary of the 200-West Area.

Two wells monitoring the State-Approved Land Disposal Site just north of the 200-West Area showed tritium activities that exceeded the drinking water standard, with one of the wells showing a maximum value (2,100,000 pCi/L) that exceeded the derived concentration guide in 1998. These activities are associated with the disposal site, which receives treated effluent containing tritium. This disposal site has been in operation since 1995.

Tritium in the 300 Area. The eastern portion of the tritium plume that emanates from the 200-East Area continues to move to the east-southeast and discharge into the Columbia River (see Figure 6.1.13). The southern edge of the tritium plume extends into the 300 Area, as shown in Figure 6.1.18. Figure 6.1.19 shows the trend of tritium activities in well 699-S19-E13 just north of the 300 Area. Tritium in this well decreased slightly in 1998 after reaching a maximum in 1997. Even though tritium in the 300 Area is below the drinking water standard, a concern has been the potential migration of the tritium plume to an offsite municipal water supply to the south. The municipal water supply consists of the city of Richland's well field recharge basins (see Figure 6.1.18).

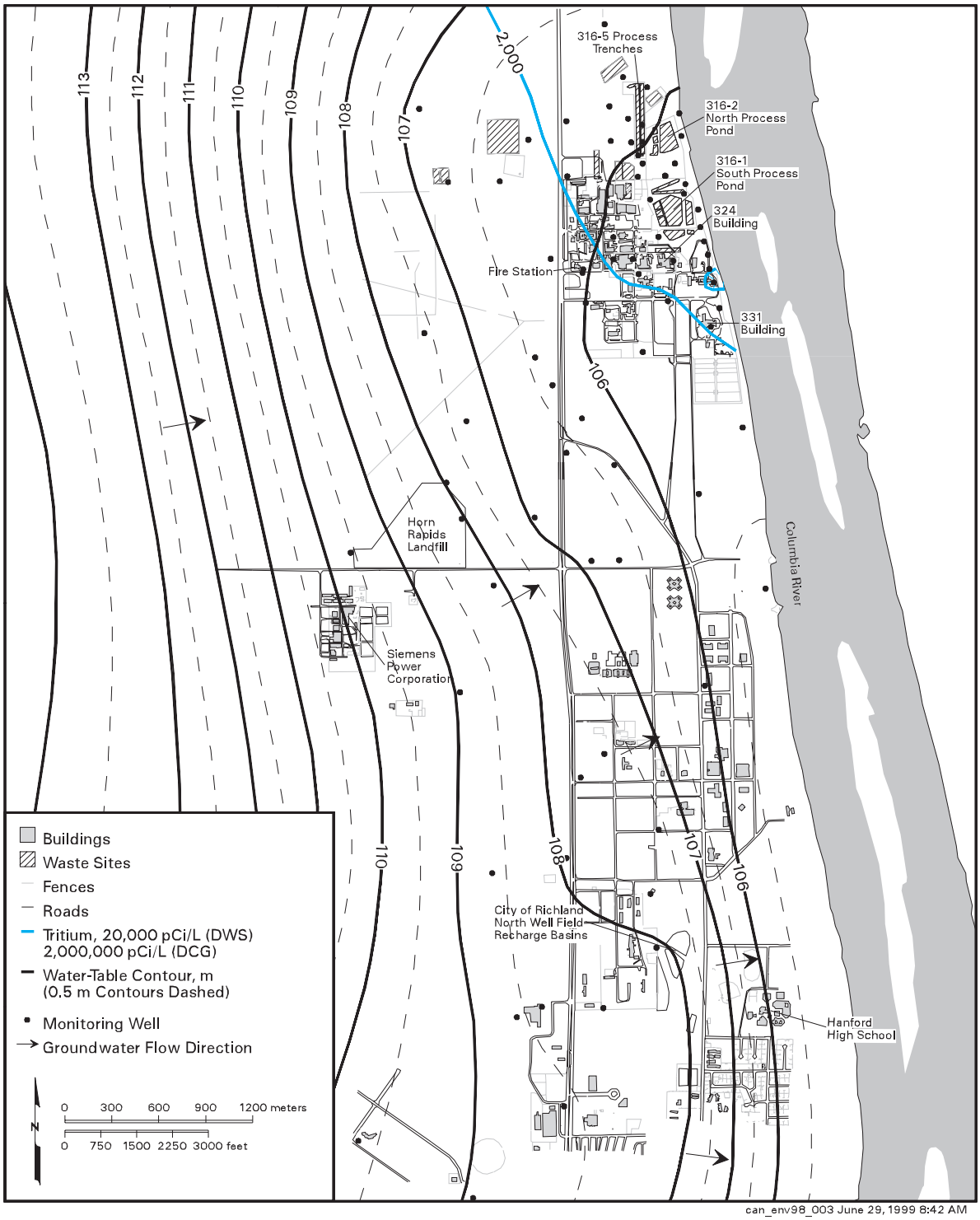


Figure 6.1.18. Average Tritium Activities and Groundwater Flow Near the 300 Area, 1998

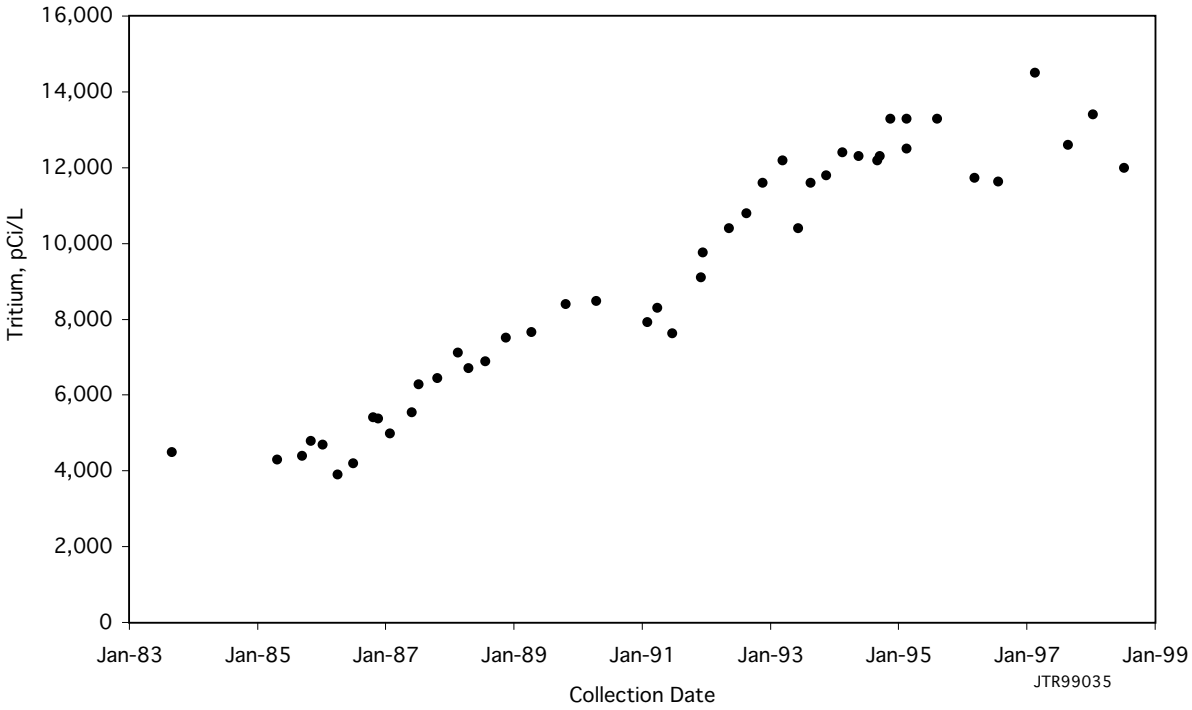


Figure 6.1.19. Tritium Activities in Well 699-S19-E13, 1983 Through 1998

The tritium plume is not expected to impact the well field recharge basins because of the influence of groundwater flow from the Yakima River, recharge from agricultural irrigation, and recharge from infiltration ponds at the well field (see Figure 6.1.18). The Yakima River is at a higher elevation and recharges the groundwater in this area. As a result, groundwater flows from west to east (see Figure 6.1.18), minimizing the southward movement of the contaminant plume. Recharge from agricultural irrigation occurs south of the Hanford Site boundary and also contributes to eastward flow. The recharge basins are supplied with Columbia River water, which infiltrates to the groundwater. The amount of recharge water exceeds the amount pumped at the well field by a factor of approximately 2:1, resulting in groundwater flow away from the well field. This further ensures that tritium-contaminated groundwater will not reach the well field. Ongoing monitoring is performed to confirm this interpretation.

Tritium in the 400 Area. The tritium plume that originated in the 200-East Area extends under the 400 Area. The observed maximum in this area during 1998 was 36,300 pCi/L in well 499-S1-8K. The primary water supply well for the 400 Area (499-S1-8J) is completed in the lower part of the aquifer and had a maximum tritium activity of 19,500 pCi/L. However, the sample may have been switched and mislabeled with a sample from a backup water supply well. The average activity in the primary water supply in 1998 was 5,947 pCi/L. The activities at wells used for backup water supply (499-S0-7 and 499-S0-8) were above the drinking water standard. The maximum in the backup water supply was 31,500 pCi/L, which is an increase from 1997 levels. The water supply wells are located in the northern part of the 400 Area. Additional information on the 400 Area water supply is provided in Section 4.3, "Hanford Site Drinking Water Surveillance."

Samples collected from wells near the 400 Area Process Ponds showed a maximum tritium activity (22,300 pCi/L) that exceeded the drinking water standard. The 400 Area Process Ponds are located in the 600 Area north of the 400 Area. Discharge of wastewater to this facility does not contribute tritium contamination to groundwater because the source of the wastewater is water supply usage from local groundwater wells.

Iodine-129. Iodine-129 has a relatively low drinking water standard (1 pCi/L), has the potential for accumulation in the environment as a result of long-term releases from nuclear fuel reprocessing facilities (Soldat 1976), and has a long half-life (16,000,000 yr). The relatively low fission yield for production of iodine-129 combined with its long half-life limits its specific activity in Hanford Site wastes. Iodine-129 may be released as a vapor during fuel dissolution and other elevated temperature processes and, thus, may be associated with process condensate wastes. At the site, the main contributor of iodine-129 to groundwater has been liquid discharges to cribs in the 200 Areas. Iodine-129 has essentially the same high mobility in groundwater as tritium. No groundwater samples showed iodine-129 activities above the 500-pCi/L derived concentration guide in 1998.

Iodine-129 in the 200-East Area. The highest iodine-129 activities in the 200-East Area are in the northwest near the BY Cribs and in the southeast near the Plutonium-Uranium Extraction Plant. The maximum level of iodine-129 detected in 1998 in the 200-East Area was 12.9 pCi/L south of the Plutonium-Uranium Extraction Plant near the 216-A-10 Crib. The iodine-129 plume extends from the Plutonium-Uranium Extraction Plant area southeast into the 600 Area and appears coincident with the tritium plumes (see Figure 6.1.13). The plume appears smaller than the tritium plume because of the lower initial activity of iodine-129. The iodine-129 contamination can be detected as far east as the Columbia River but at levels below the drinking water standard. Data indicate that iodine-129 at levels above the drinking water standard is approaching the Columbia River (Figure 6.1.20). The plume likely had the same sources as the tritium plume. Iodine-129 is also present in groundwater at levels above the drinking water standard in the northwestern 200-East Area; however, a definite source for this plume has not been determined. This plume extends northwest into the gap between Gable Mountain and Gable Butte.

Iodine-129 in the 200-West Area. The distribution of iodine-129 in Hanford Site groundwater is shown in Figure 6.1.20. The highest level observed in 1998 was 81.4 pCi/L near the T, TX, and TY Tank Farms in the northern part of the 200-West Area. This level occurs in a plume that originates near the tank farms and nearby disposal facilities and extends northeast toward T Plant. The iodine-129 plume is coincident with the technetium-99 and tritium plumes in this area. A much larger iodine-129 plume occurs in the southeastern part of the 200-West Area, which originates near the Reduction-Oxidation Plant, and extends east into the 600 Area. This plume is essentially coincident with the tritium plume, though there appears to be a contribution from cribs to the north near U Plant. In 1998, the maximum in this plume was 49.6 pCi/L in an area east of the Reduction-Oxidation Plant.

Technetium-99. Technetium-99, which has a half-life of 210,000 yr, is produced as a fission byproduct and is present in waste streams associated with fuel reprocessing. Reactor operations may also result in the release of some technetium-99 associated with fuel element breaches. Under the chemical conditions that exist in Hanford Site groundwater, technetium-99 is normally present in solution as anions that sorb poorly to sediments. Therefore, technetium-99 is very mobile in site groundwater.

Technetium-99 was found at activities greater than the 900-pCi/L interim drinking water standard in the 200-East and 200-West Areas, with the highest

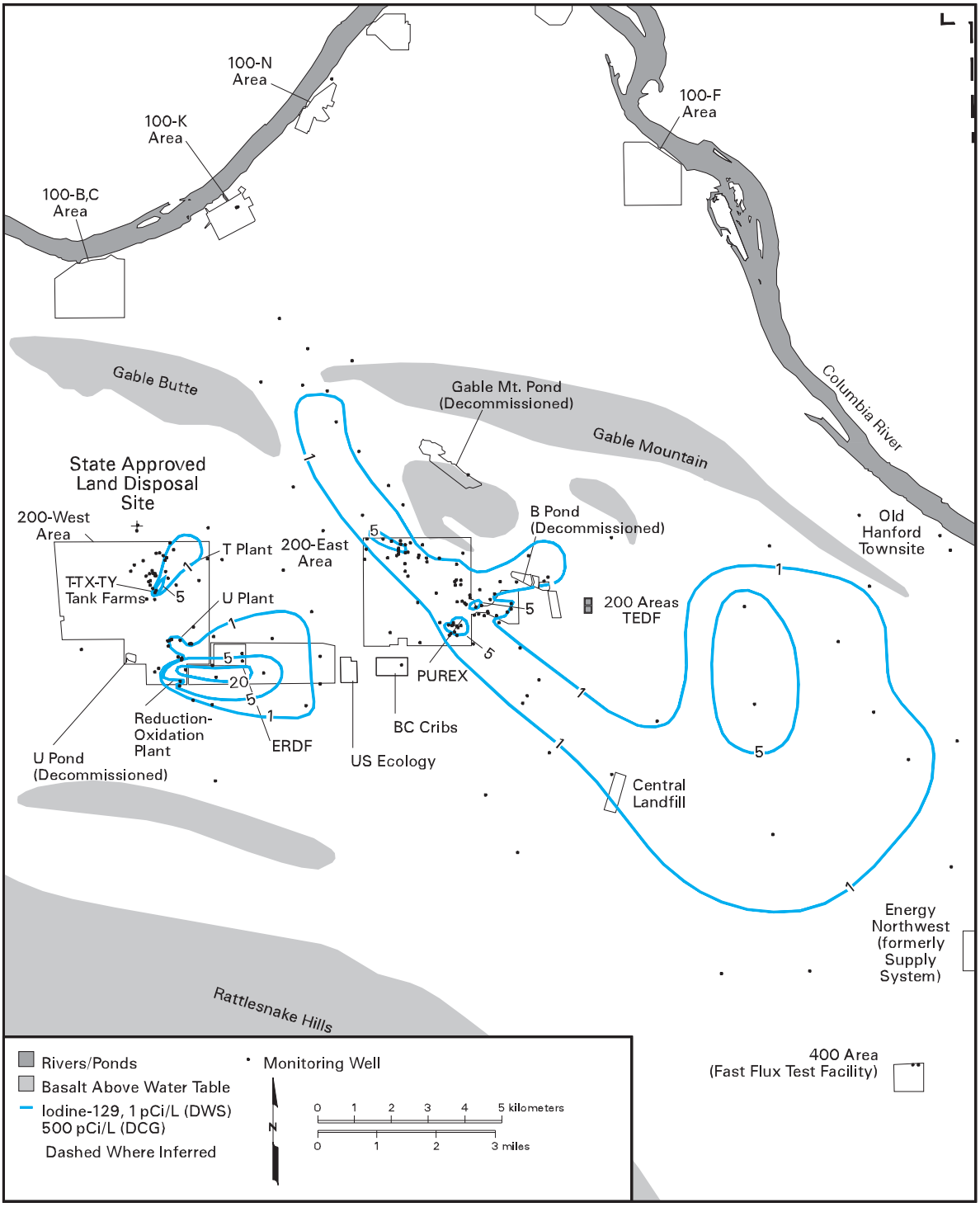


Figure 6.1.20. Average Iodine-129 Activities in the Unconfined Aquifer, 1998

measured in the 200-West Area. In the 100-H Area, levels in a localized area fell below the interim drinking water standard in 1998. The derived concentration guide for technetium-99 is 100,000 pCi/L.

Technetium-99 in the 200-East Area. Groundwater in the northwestern part of the 200-East Area and a part of the 600 Area north of the 200-East Area contains technetium-99 at activities above the interim drinking water standard (Figure 6.1.21). The source of these technetium plumes was apparently the BY Cribs (Section 5.8.2 in PNL-10698). However, some of this contamination is believed to originate from the B, BX, and BY Tank Farms (PNNL-11826). Technetium-99 increased in several monitoring wells during 1998, creating a new local center of high technetium-99 levels in the area north and west of the tank farms. The largest increase occurred in the northwestern corner of the BY Cribs, where the maximum in the 200-East Area was 7,030 pCi/L. The maximum technetium-99 in the plume north of the 200-East Area in 1998 was 2,210 pCi/L. This plume appears to be moving through the gap between Gable Mountain and Gable Butte.

Technetium-99 in the 200-West Area. The largest technetium-99 plume in the 200-West Area originates from the cribs that received effluent from U Plant and extends into the 600 Area to the east (Figure 6.1.22). The technetium plume is approximately in the same location as the uranium plume because technetium-99 and uranium, which are typically associated with the same fuel reprocessing cycle, were disposed to the same cribs. The highest technetium-99 activities in this plume in 1998 were measured in several wells in the vicinity of the 216-U-17 Crib, where remediation by the pump-and-treat method is occurring. The high-activity portion of the plume, which has decreased in size, appears to be moving downgradient toward the extraction center (well 299-W19-39). The maximum level was detected in well 299-W19-29 at a level of 22,600 pCi/L, the highest observed at the Hanford Site. This well is located approximately midway between the 216-U-1, 216-U-2, and the 216-U-17 Cribs. Technetium-99 activities in the extraction well decreased in 1998.

The purpose of the pump-and-treat system near the 216-U-17 Crib is to contain and reduce the highest activities/concentrations in the technetium-99 and uranium plumes (Record of Decision 1997). As of September 1998, approximately 53.9 g (1.9 oz) of technetium-99 have been removed from approximately 338 million L (89 million gal) of extracted groundwater since pump-and-treat operations began in 1994 (DOE/RL-99-02). This mass of technetium-99 is equivalent to approximately 0.9 Ci of radioactivity. Contaminated groundwater is currently pumped from one extraction well (299-W19-39) and transported via pipeline to the 200 Areas Effluent Treatment Facility, where it is treated using a number of processes. The treated groundwater is disposed of to the State-Approved Land Disposal Site north of the 200-West Area.

Technetium-99 occurs at levels above the interim drinking water standard in the vicinity of the T, TX, and TY Tank Farms (see Figure 6.1.22). Four wells that monitor these tank farms consistently showed technetium-99 activities above the interim drinking water standard in 1998. Near the TX and TY Tank Farms, the highest was 3,680 pCi/L in the southwestern corner of the tank farms (well 299-W15-22), where technetium-99 levels have been increasing. In the northeastern corner of T Tank Farm, technetium-99 levels were above the interim drinking water standard in two wells. The maximum in this area was 13,000 pCi/L in 1998 (well 299-W11-27). The sources of this technetium-99 contamination were the T, TX, and TY Tank Farms (PNNL-11809).

The small plume in the southern part of the 200-West Area originates near the S and SX Tank Farms and the 216-S-13 Crib. The maximum detected in this area was approximately 4,330 pCi/L near the southeastern corner of the SX Tank Farm. Leakage

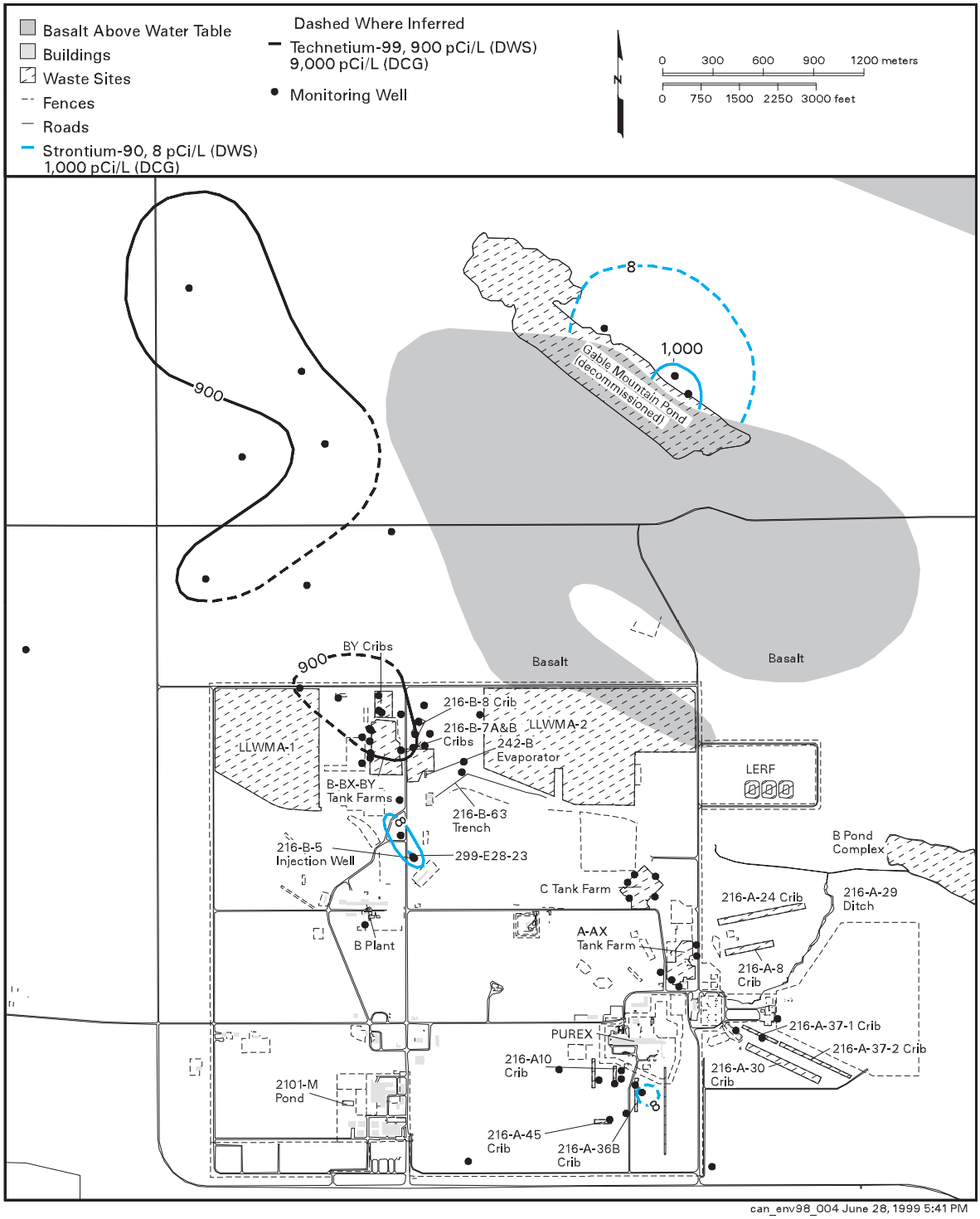


Figure 6.1.21. Average Technetium-99 and Strontium-90 Activities in the Unconfined Aquifer Near the 200-East Area, 1998

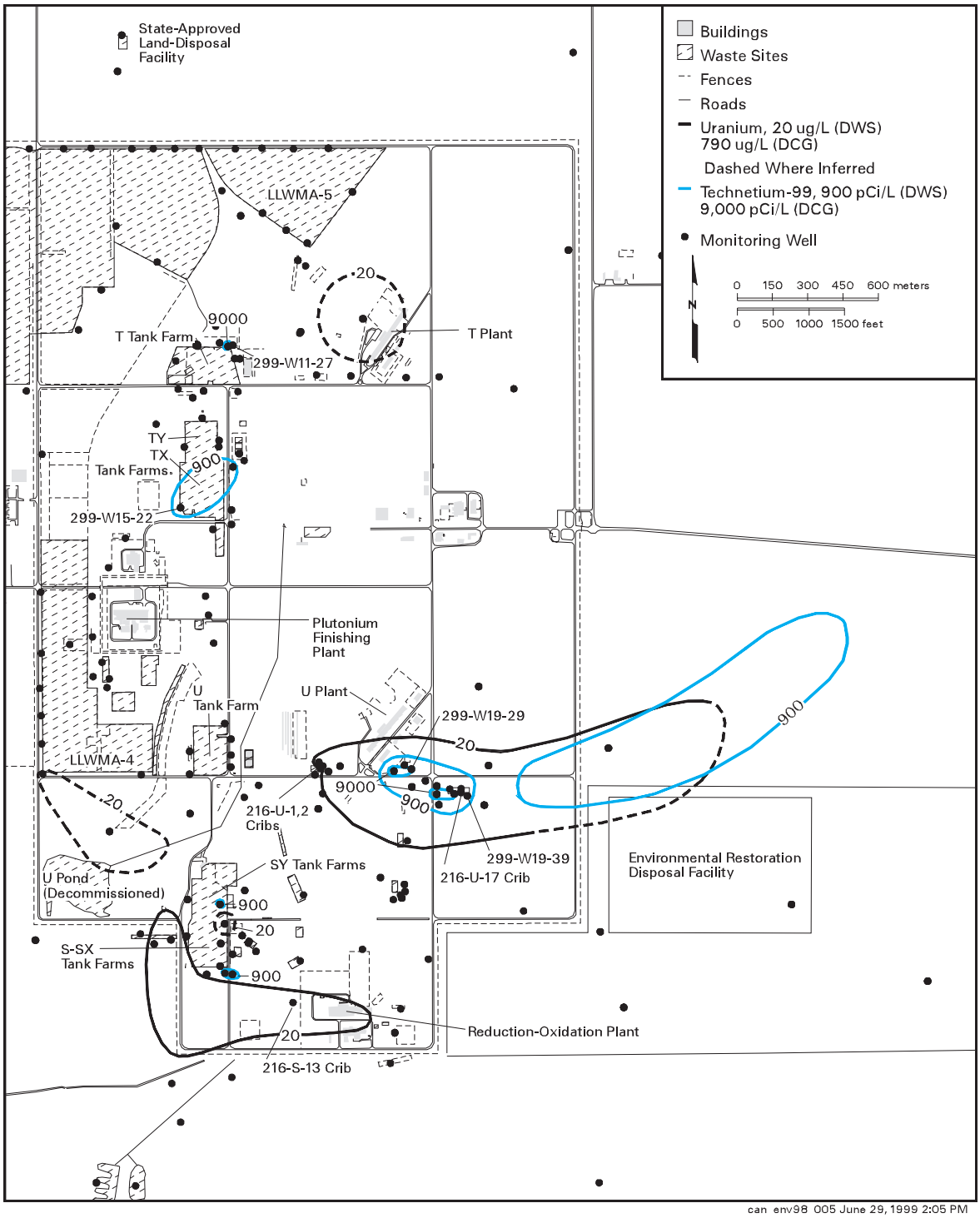


Figure 6.1.22. Average Technetium-99 Activities and Uranium Concentrations in the Unconfined Aquifer in the 200-West Area, 1998

from the single-shell tanks is believed to be a source of the technetium-99 in this vicinity (PNNL-11810).

Uranium. There were numerous possible sources of uranium released to the groundwater at the Hanford Site, including fuel fabrication, fuel reprocessing, and uranium recovery operations. Uranium may exist in several states, including elemental uranium or uranium oxide as well as tetravalent and hexavalent cations. Only the hexavalent form has significant mobility in groundwater, largely by forming dissolved carbonate species. Uranium mobility is thus dependent on both oxidation state and pH. Uranium is observed to migrate in site groundwater but is retarded relative to more-mobile species such as technetium-99 and tritium. The EPA's proposed drinking water standard is 20 μg/L for uranium. The derived concentration guide that represents an annual effective dose equivalent of 100 mrem/yr is 790 μg/L for uranium.

Uranium has been detected at concentrations greater than the proposed drinking water standard in portions of the 100, 200, 300, and 600 Areas. The highest levels detected at the Hanford Site in 1998 were in the 200-West Area near U Plant, where uranium levels exceeded the derived concentration guide.

Uranium in the 100 Areas. In 1998, uranium was detected at a concentration greater than the 20-μg/L proposed drinking water standard in one well near F Reactor in the 100-F Area. The maximum detected was 20.3 μg/L.

Uranium was detected at levels higher than the proposed drinking water standard in three wells in the 100-H Area. The maximum detected in 1998 was 57 μg/L. Past leakage from the 183-H Solar Evaporation Basins is considered to be the source of the 100-H Area uranium contamination. These basins were remediated in 1996.

Uranium in the 200-East Area. In 1998, several wells in the northwestern part of the 200-East Area contained uranium at levels greater than the proposed drinking water standard. The distribution of uranium in this area suggests that contamination is of limited extent, with the highest concentrations in the vicinity of the B, BX, and BY Tank Farms; BY Cribs; and 216-B-5 Injection Well that has been inactive since 1947. The highest detected was 282 μg/L east of the BY Tank Farm (southeast of the BY Cribs). The source of the uranium contamination in this area is unclear. Near the inactive 216-B-5 Injection Well, one well showed a uranium concentration greater than the proposed drinking water standard. The concentration at this well was 69 μg/L. Near B Plant, uranium concentrations have been increasing in one well and reached 20 μg/L in 1998. One well adjacent to the inactive 216-B-62 Crib showed a concentration of 21 μg/L in 1998.

Uranium in the 200-West Area. The highest uranium concentrations in Hanford Site groundwater occurred near U Plant, at wells adjacent to the inactive 216-U-1, 216-U-2, and 216-U-17 Cribs (see Figure 6.1.22). The uranium plume, which extends into the 600 Area to the east, is approximately in the same location as the technetium-99 plume discussed above. Uranium and technetium-99 are typically associated with the same fuel reprocessing cycle and were disposed to the same cribs. The high concentrations exceeded the derived concentration guide for uranium. The maximum detected in this area in 1998 was 2,800 μg/L adjacent to the 216-U-17 Crib. Uranium concentrations in this area have been increasing as a result of a pump-and-treat operation at an extraction well (299-W19-39) located near the 216-U-17 Crib. However, the size of the overall plume did not change significantly between 1997 and 1998.

As of September 1998, the pump-and-treat system removed a total of 80.4 kg (177 lb) of uranium from approximately 338 million L (89 million gal) of extracted groundwater since operations began in 1994 (DOE/RL-99-02).

Other areas with uranium contamination at levels above the proposed drinking water standard are also shown in Figure 6.1.22, including fairly widespread areas west and northwest of the Reduction-Oxidation Plant. Uranium concentrations in those areas are considerably lower than the concentrations detected near U Plant. The maximum uranium in these areas was 90.5 μg/L immediately east of the S and SX Tank Farms (northwest of the Reduction-Oxidation Plant). In the northern part of the 200-West Area, a localized area of uranium contamination, where a single sample showed a concentration above the proposed drinking water standard, was found near T Plant.

Uranium in the 300 Area. A plume of uranium contamination exists in the vicinity of uranium fuel fabrication facilities and inactive sites known to have received uranium waste. The plume extends downgradient from inactive liquid waste disposal facilities to the Columbia River (Figure 6.1.23). The major source of the contamination is the inactive 316-5 Process Trenches, as indicated by the distribution of the uranium concentrations downgradient from these trenches (see Section 5.13.3.1 in PNNL-12086). Movement of the plume toward the Columbia River has resulted in increased uranium concentrations near the river in recent years, as shown by the trend plots for wells 399-2-1 and 399-2-2 in Figure 6.1.23. The maximum detected in 1998 was 252 μg/L. Elevated concentrations at the south end of the 316-5 Process Trenches indicate that the soil column is contributing uranium contamination to the groundwater.

A localized area of elevated levels of uranium between the 324 Building and the Columbia River showed a maximum concentration of 128 μg/L in 1998 (see Figure 6.1.23).

Uranium in the 600 Area. The uranium concentration in a well southeast of the 400 Area (adjacent to Route 4S) decreased to a maximum of 91.3 μg/L in 1998. The contamination at this well is attributed to the nearby inactive 316-4 Crib (Section 5.12.3.3 in PNNL-11793). The retired 618-10 Burial Grounds are also located near this well.

Strontium-90. Strontium-90 was produced as a high-yield fission product and was present in waste streams associated with fuel reprocessing. Reactor operations also resulted in the release of some strontium-90 associated with fuel element breaches. Strontium-90 mobility in Hanford Site groundwater is reduced by adsorption onto sediment particles. However, strontium-90 is moderately mobile in groundwater because its adsorption is much weaker than for other radionuclides such as cesium-137 and plutonium. Because of sorption, a large proportion of the strontium-90 in the subsurface is not present in solution. The half-life of strontium-90 is 29.1 yr.

In 1998, strontium-90 activities at greater than the 8-pCi/L interim drinking water standard were found in one or more wells in each of the 100, 200, and 600 Areas. Levels of strontium-90 were greater than the 1,000-pCi/L derived concentration guide in portions of the 100, 200, and 600 Areas. The 100-N Area had the widest distribution with the highest activities detected at the Hanford Site during 1998.

Strontium-90 in the 100 Areas. Strontium-90 activities greater than the interim drinking water standard extend from the B Reactor complex to the Columbia River in the northeastern part of the 100-B,C Area (Figure 6.1.24). The highest continued to be found in wells near the inactive 116-B-1 and 116-C-1 Trenches. The maximum detected in 1998 was 170 pCi/L near the inactive 116-C-1 Trench. The sources for the strontium-90 appear to be liquid waste disposal sites near B Reactor and liquid overflow trenches near the Columbia River (DOE/EIS-0119F).

Strontium-90 is not widely distributed in the 100-D Area. One well continues to show levels that are consistently greater than the interim drinking water standard near the inactive D Reactor fuel

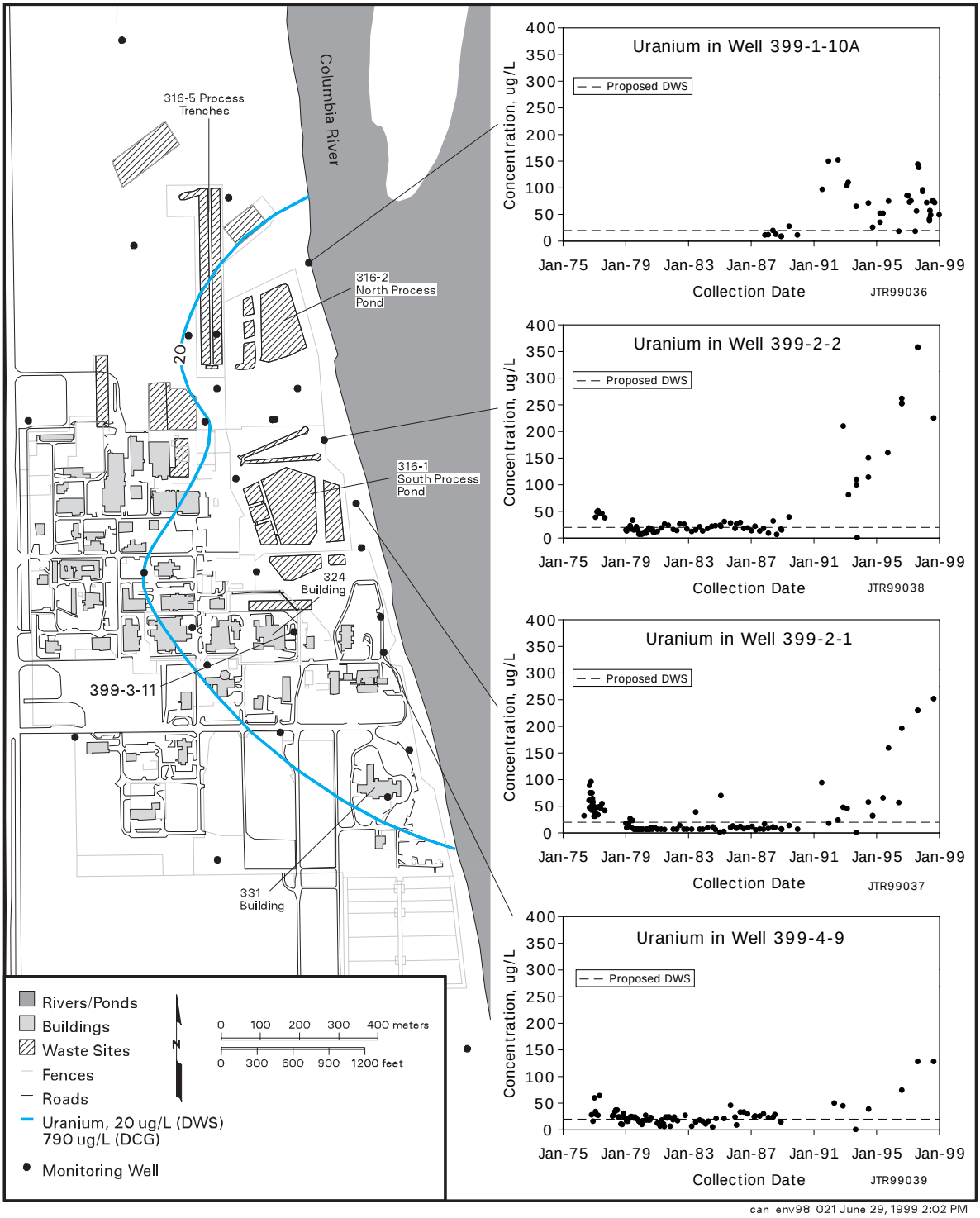


Figure 6.1.23. Average Uranium Concentrations in the Unconfined Aquifer in the 300 Area, 1998, and Concentration Trends for Select Wells

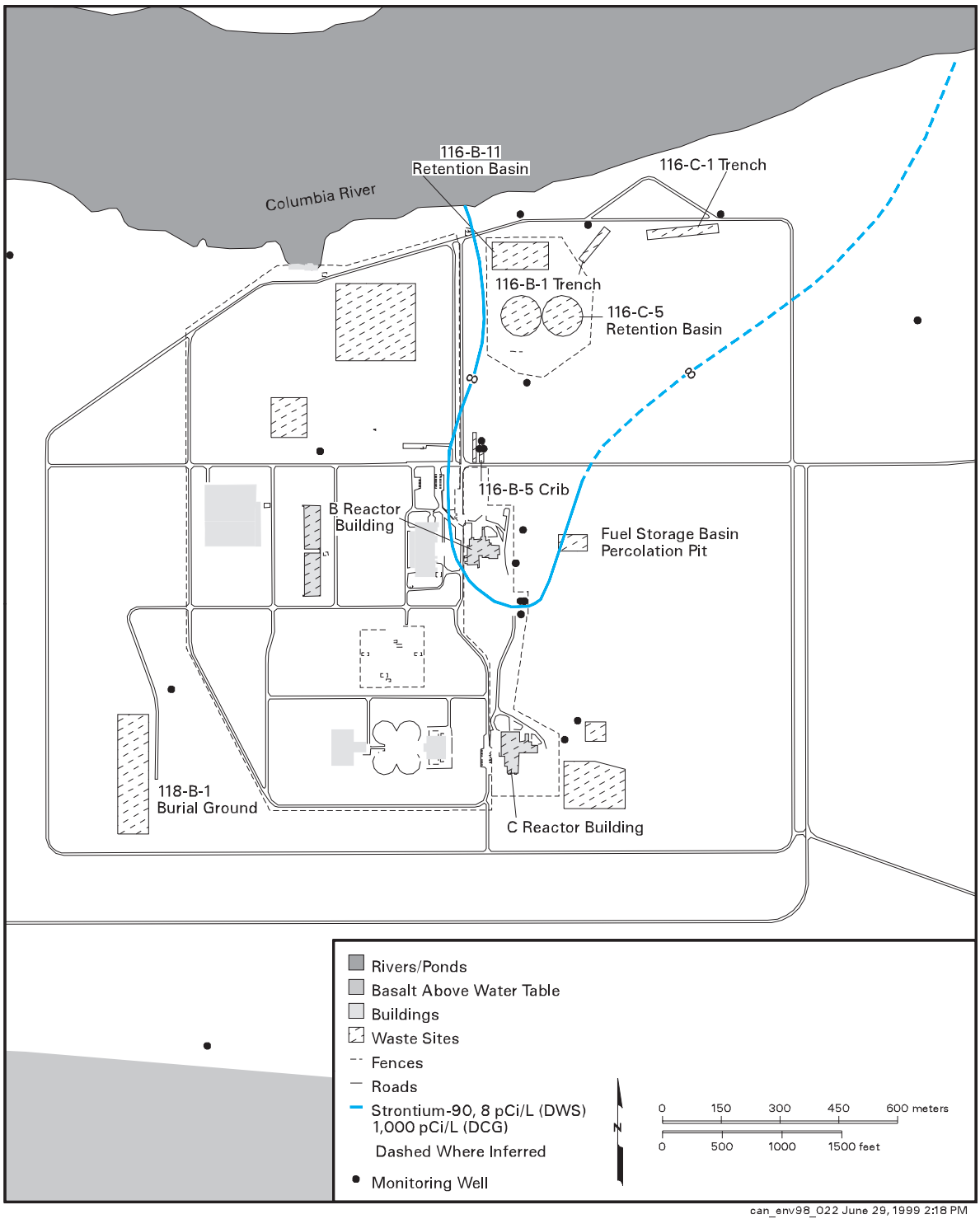


Figure 6.1.24. Average Strontium-90 Activities in the Unconfined Aquifer in the 100-B,C Area, 1998

storage basin. The maximum level was 42 pCi/L in 1998. Strontium-90 was detected at levels greater than the interim drinking water standard in well 199-D8-68 near the former 116-D-7 Retention Basin in the northern part of the 100-D Area.

Strontium-90 exceeded the interim drinking water standard in several wells near the 116-F-14 Retention Basins and 116-F-2 Trench in the eastern part of the 100-F Area. The maximum detected in 1998 was 359 pCi/L.

In the 100-H Area, strontium-90 contamination levels greater than the interim drinking water standard were present in an area adjacent to the Columbia River near the 107-H Retention Basin. The maximum detected in the 100-H Area in 1998 was 50 pCi/L between the retention basin and the Columbia River. The source of the contamination is past disposal of liquid effluent containing strontium-90 to retention basins and trenches in the 100-H Area.

Strontium-90 at levels greater than the interim drinking water standard continues to show up in isolated areas in the 100-K Area. These areas include the vicinity of the KE and KW Reactors and between the 116-K-2 Liquid Waste Disposal Trench and the Columbia River. The maximum detected in 1998 was 6,290 pCi/L at well 199-K-109A, the only well in the 100-K Area where levels were above the derived concentration guide. The original source of the strontium-90 in this well, located near the KE Reactor, is believed to be the former 116-K-3 Injection Well/Drain Field. Maximum strontium-90 activities near the KW Reactor and the disposal trench were significantly lower than those near KE Reactor by approximately two orders of magnitude.

The distribution of strontium-90 in the 100-N Area is shown in Figure 6.1.25. Strontium-90 was detected at activities greater than the derived concentration guide in several wells located between the 1301-N Liquid Waste Disposal Facility, a source of the strontium-90, and the Columbia River. The 1325-N Liquid Waste Disposal Facility is also a source of strontium-90 in groundwater. The maximum level detected in 1998 was 26,000 pCi/L near the head end of the 1301-N facility (well 199-N-67). Strong, positive correlations between high-elevation groundwater levels and high-strontium-90 activities in wells indicate that strontium-90 is remobilized during periods of high water levels.

Strontium-90 discharges to the Columbia River through springs along the shoreline in the 100-N Area. Section 4.2, "Surface Water and Sediment Surveillance" and Section 3.2, "Near-Facility Environmental Monitoring," give the results of springs water sampling. Because of large levels in wells near the river, it was expected that strontium-90 exceeded the interim drinking water standard at the interface between the groundwater and the river (DOE/RL-96-102). Groundwater contaminated with strontium-90 entering the river could potentially reach an aquatic and riparian ecological receptor through direct uptake.

A pump-and-treat method began in 1995 to remove strontium-90 in the 100-N Area. The objective is to pump from the extraction wells to create a hydraulic barrier between the river and the 1301-N facility, thus reducing the volume of contaminated groundwater to the river. The pump-and-treat system, which uses ion-adsorption technology, removed approximately 0.1 Ci of strontium-90 from extracted groundwater during fiscal year 1998 (DOE/RL-99-02). This is compared to an estimated total of 76 to 88 Ci in the aquifer (in groundwater and adsorbed on the saturated sediments) (DOE/RL-95-110).

Strontium-90 in the 200 Areas. Strontium-90 distribution in the 200-East Area is shown in Figure 6.1.21. Strontium-90 activities in the 200-East Area were above the derived concentration guide in two wells near the inactive 216-B-5 Injection Well. The maximum was 10,800 pCi/L in well 299-E28-23. This injection well received an estimated 27.9 Ci of strontium-90 during 1945 and 1946 (PNL-6456). Strontium-90 was detected at a level above the

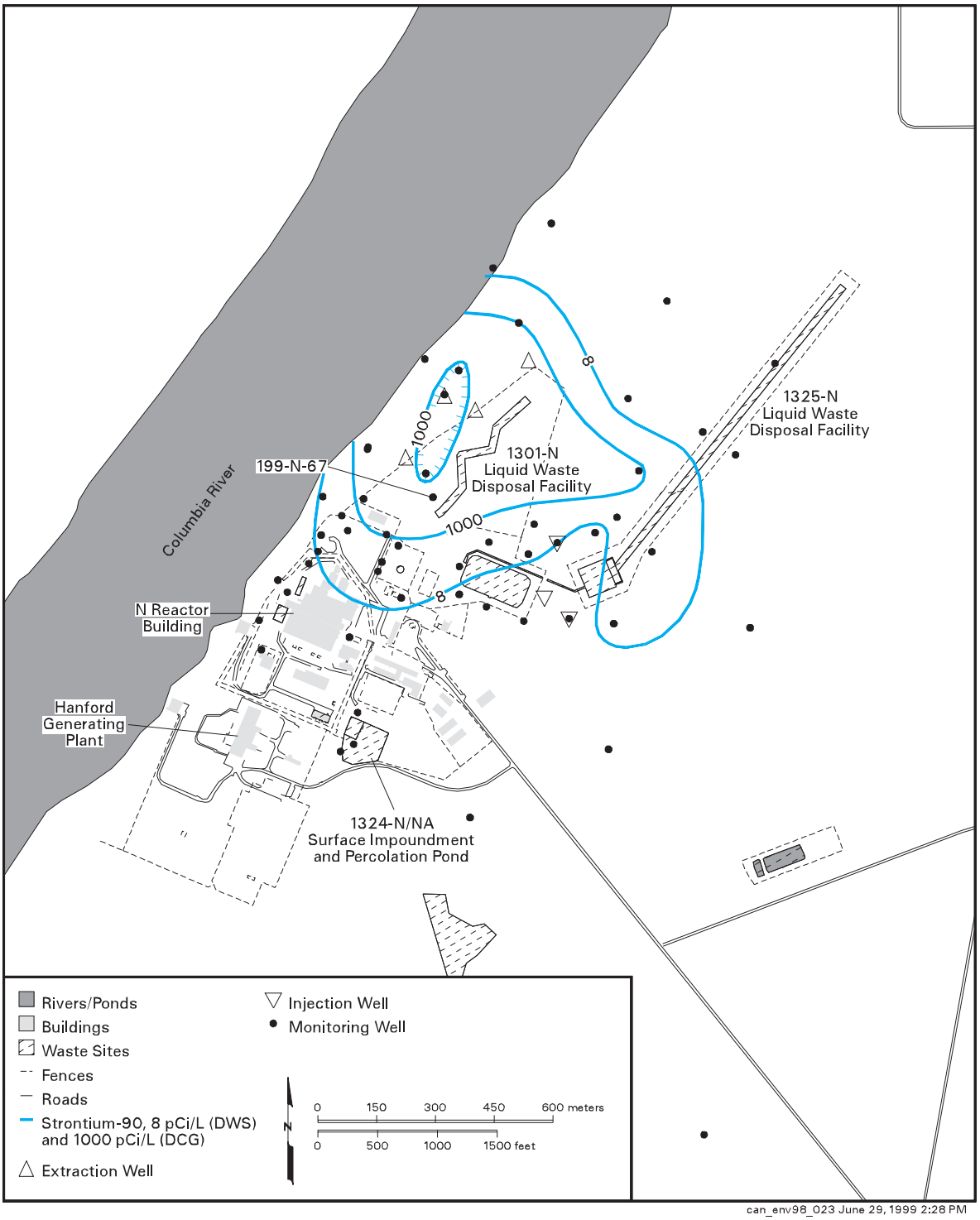


Figure 6.1.25. Average Strontium-90 Activities in the Unconfined Aquifer in the 100-N Area, 1998

interim drinking water standard in one well near the Plutonium-Uranium Extraction Plant cribs in the 200-East Area and in one well near the Reduction-Oxidation Plant cribs in the 200-West Area.

Strontium-90 in the 600 Area. In the 600 Area, the highest strontium-90 activities were detected in four wells in the former Gable Mountain Pond area (see Figure 6.1.21). In three of the wells, levels exceeded the derived concentration guide and reached a maximum of 1,350 pCi/L in 1998. Strontium-90 contamination in this area resulted from the discharge of radioactive liquid waste to the former Gable Mountain Pond during its early use.

Carbon-14. Carbon-14 activities are widely distributed in the 100-K Area and exceed the 2,000-pCi/L interim drinking water standard in two plumes near the KE and KW Reactors (Figure 6.1.26). The sources of the carbon-14 were the 116-KE-1 and 116-KW-1 Cribs, respectively. The maximum in 1998 was 35,000 pCi/L near the 116-KW-1 Crib. The derived concentration guide for carbon-14 is 70,000 pCi/L. Carbon-14 has a half-life of 5,730 yr.

Cesium-137. Cesium-137, which has a half-life of 30 yr, is produced as a high-yield fission product and is present in waste streams associated with fuel processing. Former reactor operations also may have resulted in the release of some cesium-137 associated with fuel element breaches. Cesium-137 is normally strongly sorbed on soil and, thus, is very immobile in Hanford Site groundwater. The interim drinking water standard for cesium-137 is 200 pCi/L; the derived concentration guide is 3,000 pCi/L.

Cesium-137 was detected in three wells located near the inactive 216-B-5 Injection Well in the 200-East Area. The injection well received cesium-137 bearing wastes from 1945 to 1947. The maximum cesium-137 in 1998 was 1,840 pCi/L, which is greater than the interim drinking water standard. Cesium-137 appears to be restricted to the immediate vicinity of the former injection well by its extremely low mobility in groundwater.

Cobalt-60. Cobalt-60 in groundwater is typically associated with wastes generated by reactor effluent. Cobalt-60 is normally present as a divalent transition metal cation and, as such, tends to be highly immobile in groundwater. However, complexing agents may mobilize it. All groundwater samples analyzed for cobalt-60 in 1998 were below the 100-pCi/L interim drinking water standard. The derived concentration guide for cobalt-60 is 5,000 pCi/L.

Cobalt-60 activities were less than the interim drinking water standard in the northwestern part of the 200-East Area and the adjacent 600 Area north of the 200-East Area, which are the same areas where the technetium-99 contamination associated with the BY Cribs is found. Apparently, cobalt in this plume is mobilized by reaction with cyanide or ferrocyanide in the waste stream, forming a dissolved cobalt species. The maximum measured in 1998 was 66 pCi/L at the BY Cribs. Because of its relatively short half-life (5.3 yr), much of the cobalt-60 in groundwater in this area has decayed to lower activities.

Plutonium. Plutonium has been released to the soil column in several locations in both the 200-West and 200-East Areas. Plutonium is generally considered to sorb strongly to sediments and, thus, has limited mobility in the aquifer. The derived concentration guide for both plutonium-239 and plutonium-240 is 30 pCi/L. Analytical detection is incapable of distinguishing between plutonium-239 and plutonium-240; thus, the results are expressed as a concentration of plutonium-239,240. There is no explicit drinking water standard for plutonium-239,240; however, the gross alpha drinking water standard of 15 pCi/L would be applicable at a minimum. Alternatively, if the derived concentration guide that is based on a 100-mrem dose standard is converted to the 4-mrem dose equivalent used for the drinking water standard, 1.2 pCi/L would be the relevant guideline. The half-lives of plutonium-239 and plutonium-240 are 24,000 and 6,500 yr, respectively.

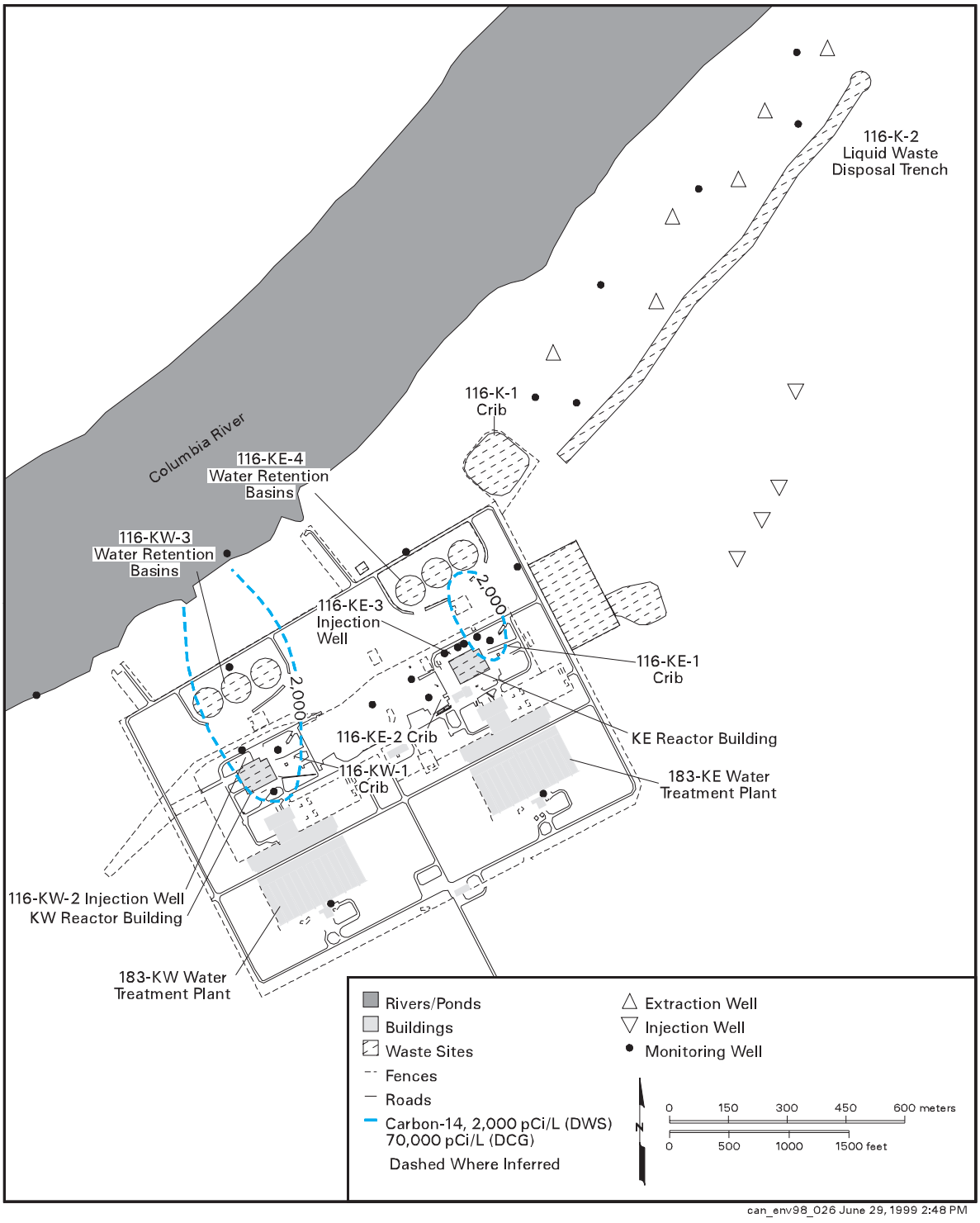


Figure 6.1.26. Average Carbon-14 Activities in the 100-K Area, 1998

The only location where plutonium isotopes were detected in groundwater was near the inactive 216-B-5 Injection Well in the 200-East Area. Groundwater sampled during 1998 at wells located near this injection well ranged up to 66 pCi/L of plutonium-239,240. Because plutonium is strongly adsorbed to sediments and may have been injected into the aquifer as suspended particles, it is likely that the values measured result in part from solid rather than dissolved material. The injection well received an estimated 244 Ci of plutonium-239,240 during its operation from 1945 to 1947 (PNL-6456).

6.1.6.2 Chemical Monitoring Results for the Unconfined Aquifer

In recent years, chemical analyses performed by various monitoring programs at the Hanford Site have identified several hazardous chemicals in groundwater at concentrations greater than their respective drinking water standards. Nitrate, chromium, and carbon tetrachloride are the most widely distributed of these hazardous chemicals and have the highest concentrations in groundwater at the Hanford Site. Chemicals that are less widely distributed and have lower concentrations in groundwater include chloroform, trichloroethylene, tetrachloroethylene, cis-1,2-dichloroethylene, cyanide, and fluoride.

A number of parameters such as pH, specific conductance, total carbon, total organic carbon, and total organic halides are used as indicators of contamination. These are mainly discussed in Section 6.1.7, "RCRA Summary." Other chemical parameters listed in Table 6.1.3 are indicators of the natural chemical composition of groundwater and are usually not contaminants from operations at the Hanford Site. These include alkalinity, aluminum, calcium, iron, magnesium, manganese, potassium, silica, and sodium. Chloride and sulfate occur naturally in groundwater and can also be introduced as contaminants from site operations. There is no primary drinking water standard for chloride or sulfate. The secondary standard for each is 250 mg/L and is based on aesthetic rather than health considerations; therefore, they will not be discussed in detail. The analytical technique used to determine the concentration of metals in groundwater provides results for a number of constituents such as antimony, barium, beryllium, boron, cadmium, copper, nickel, silver, strontium, vanadium, and zinc that are rarely observed at greater than background concentrations.

The following presents a summary of the chemical constituents in groundwater at concentrations greater than existing or proposed drinking water standards (40 CFR 141 and EPA 822-R-96-001; see Appendix C).

Nitrate. Many groundwater samples collected in 1998 were analyzed for nitrate. Nitrate was measured at concentrations greater than the drinking water standard (45 mg/L as nitrate ion) in wells in all operational areas. Nitrate is associated primarily with process condensate liquid wastes, though other liquids discharged to the ground also contained nitrate. Nitrate contamination in the unconfined aquifer reflects the extensive use of nitric acid in decontamination and chemical reprocessing operations. However, additional sources of nitrate are located off the site to the south, west, and southwest. The distribution of nitrate on the Hanford Site is shown in Figure 6.1.27; this distribution is similar to previous evaluations. Although nitrate contamination can be detected over large areas of the site, the areas impacted by levels greater than the drinking water standard are small. The widespread distribution of nitrate below the drinking water standard is shown in Figure 5.2-2 of PNNL-12086.

Nitrate in the 100 Areas. A plume containing slightly elevated levels of nitrate occurs in the northeastern part of the 100-B,C Area. In 1998, the maximum nitrate concentration in this area was 49 mg/L, which exceeded the drinking water standard.

Nitrate is found at levels greater than the drinking water standard in much of the 100-D Area. The highest nitrate level found in the 100-D Area in 1998

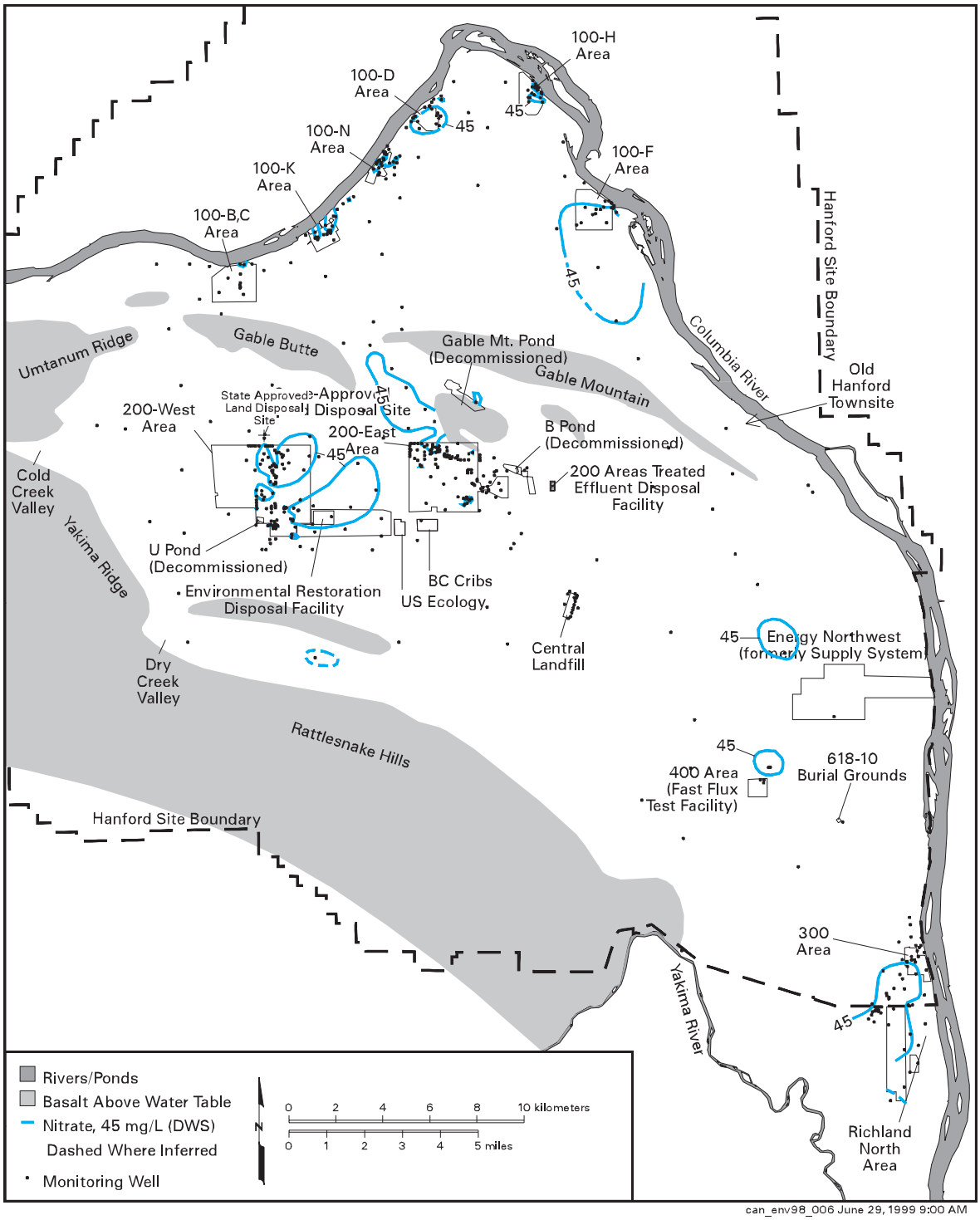


Figure 6.1.27. Average Nitrate Concentrations in the Unconfined Aquifer, 1998

was 103 mg/L, the same as in 1997, in the southwestern part of the area. Slightly lower levels were found in the northeastern part of the 100-D Area.

The central and southern portions of the 100-F Area contain nitrate in groundwater at levels greater than the drinking water standard. This plume appears to extend to the south and southeast into the 600 Area from upgradient sources near F Reactor. In the vicinity of the reactor, groundwater flow was to the south and southeast in 1998. The maximum nitrate detected in the 100-F Area in 1998 was 198 mg/L in the southwestern part of the 100-F Area.

Nitrate above the drinking water standard in the 100-H Area is restricted to a small area downgradient of the former 183-H Solar Evaporation Basins. The concentrations in this area have been some of the highest on the site; however, levels decreased in 1998. The maximum nitrate detected was 273 mg/L. The levels of nitrate exhibited in this area are related to the groundwater levels and Columbia River stage.

Nitrate at levels greater than the drinking water standard in the 100-K Area are found downgradient of both the KE and KW Reactors and appear to reach the Columbia River. The maximum concentration detected in 1998 was 175 mg/L in a well adjacent to the KE Reactor.

Although detected over most of the 100-N Area, nitrate contamination above the drinking water standard occurs at isolated locations in the 100-N Area. The areas where concentrations exceed the drinking water standard grew in size in 1998. The maximum was 280 mg/L in a well located between the 1301-N Liquid Waste Disposal Facility and the Columbia River.

Nitrate in the 200-East Area. The nitrate plume in the 200-East Area covers a nearly identical area to that of the tritium plume. However, the area with nitrate exceeding the drinking water standard is smaller than the area with tritium exceeding its drinking water standard. Nitrate exceeds the drinking water standard near the Plutonium-Uranium Extraction Plant and near cribs in the northern part of the 200-East Area. In 1998, the highest concentrations were reported in several wells near the 216-B-8 and BY Cribs. The maximum concentration in the 200-East Area was 491 mg/L in a well adjacent to the inactive 216-B-8 Crib. High nitrate concentrations in the 600 Area north of the 200-East Area, ranging up to 119 mg/L, are apparently related to past disposal practices at the BY Cribs.

High nitrate concentrations continued to be found near liquid waste disposal facilities that received effluent from Plutonium-Uranium Extraction Plant operations. Nitrate concentrations in wells near the inactive 216-A-10 and 216-A-36B Cribs generally have tended to decrease in the past few years but remained greater than the drinking water standard, even though these facilities were removed from service in 1987. The maximum nitrate concentration detected in this vicinity was 192 mg/L adjacent to the 216-A-36B Crib.

Nitrate is also elevated in a few wells near the former Gable Mountain Pond north of the 200-East Area. The highest measured concentration in this area in 1998 was 127 mg/L.

Nitrate in the 200-West Area. Nitrate concentrations greater than the drinking water standard were widespread in groundwater beneath the 200-West Area and adjacent parts of the 600 Area. The major nitrate plumes were found in wells east of U Plant and wells in the north-central part of the 200-West Area. Some of the highest nitrate concentrations across the site continued to be found in wells southeast of U Plant, where the maximum detected in 1998 was 1,673 mg/L adjacent to the inactive 216-U-17 Crib. This was the highest nitrate concentration observed on the Hanford Site in 1998. The presence of nitrate in wells near this crib was observed before February 1988 when the crib went into operation. The source of nitrate is believed to be wastes

disposed of in the 216-U-1 and 216-U-2 Cribs southwest of U Plant. These cribs received >1,000,000 kg (2,200,000 lb) of nitrate bearing chemicals during their operation from 1951 to 1967 (PNL-6456). As of September 1998, a pump-and-treat system near the 216-U-17 Crib has removed 7,910 kg (17,442 lb) of nitrate from approximately 338 million L (89 million gal) of extracted groundwater (DOE/RL-99-02).

Nitrate concentrations (maximum of 238 mg/L) continued to be elevated above the drinking water standard near other inactive cribs to the south that are associated with the U Plant and Reduction-Oxidation Plant. These elevated levels represent nitrate plumes that coalesce with the plume emanating from the U Plant area. A small, isolated plume of elevated nitrate occurs west of the Reduction-Oxidation Plant near the inactive 216-S-25 Crib and S and SX Tank Farms, where the maximum concentration was 121 mg/L.

A large area, encompassing the northern half of the 200-West Area, continued to contain nitrate in groundwater at concentrations much greater than the drinking water standard. Wells showing the highest concentrations are located near several inactive liquid waste disposal facilities that received waste from early T Plant operations. A large amount of nitrate was disposed to these cribs (e.g., approximately 2,300,000 kg [5,100,000 lb] of nitrate to the 216-T-7 Crib). Maximum concentrations in these wells in 1998 ranged up to 726 mg/L west of T Plant near the inactive T, TX, and TY Tank Farms. High concentrations of nitrate (306 mg/L) were also found in 1998 at the northeastern boundary of the 200-West Area.

A smaller area of elevated nitrate concentrations above the drinking water standard is located in the vicinity of the Plutonium Finishing Plant in the central part of the 200-West Area. The highest reported concentration was 483 mg/L near the 216-Z-9 Crib. This crib had received an estimated 1,300,000 kg (2,900,000 lb) of nitrate bearing chemicals during its operation from 1955 to 1962.

Nitrate in Other Areas. Nitrate concentrations near the city of Richland and in the former 1100 Area, Richland North Area, and adjacent parts of the 600 Area along the southern boundary of the Hanford Site are also apparently affected by offsite nitrate sources. These sources may include agriculture, food processing, urban horticulture, and nuclear fuel manufacturing at offsite commercial facilities. The part of this plume with nitrate concentrations greater than the drinking water standard extends from off the site, south of the former Horn Rapids Landfill, to the 300 Area to the northeast. The area of the nitrate plume at levels greater than the drinking water standard expanded in the southern part of the Hanford Site in 1998. The maximum nitrate concentration in 1998 was 174 mg/L on the northeastern edge of the Horn Rapids Landfill.

Although most nitrate observed on the site is the result of Hanford Site operations, elevated nitrate concentrations in wells in the western part of the site appear to be the result of increasing agricultural activity in offsite areas (e.g., Cold Creek Valley). There is no known source of nitrate in these areas associated with site operations, and the groundwater flow is from the west toward the Hanford Site facilities to the east. Nitrate levels have fluctuated considerably in wells upgradient of the 200 Areas over the past 30 yr. In Cold Creek Valley, nitrate levels have been near or greater than the drinking water standard in one well since 1985. A maximum nitrate concentration of 54 mg/L was found in a well located just north of the Rattlesnake Hills.

Nitrate was detected at levels exceeding the drinking water standard in a well downgradient of the 400 Area process ponds. These levels were attributed to a former sanitary sewage lagoon west of the process ponds. The maximum concentration observed was 97 mg/L.

High nitrate concentrations have been reported off the site in parts of Grant, Adams, and Franklin Counties to the east and north of the Hanford Site. Ryker and Jones (1995) reported that 28% of the wells sampled in this area had nitrate concentrations above the drinking water standard. The nitrate is related, in general, to fertilizer and water usage and has been increasing since the 1950s. This nitrate may impact surface-water quality (see Section 4.2, "Surface Water and Sediment Surveillance") and groundwater in the northern part of the Hanford Site north of the Columbia River.

Chromium. Use of chromium on the Hanford Site has been extensive. In the 100 Areas, sodium dichromate was added to cooling water as a corrosion inhibitor, and some residual chromium remains from that use. Chromium was used for decontamination in the 100, 200, and 300 Areas and also was used for oxidation state control in the Reduction-Oxidation Plant process. In the hexavalent form, chromium is present in an anionic state. Thus, hexavalent chromium is freely mobile in the groundwater. The drinking water standard for chromium is 100 μg/L.

Both filtered and unfiltered samples were collected for analyses of chromium and other metals from several of the wells onsite. Unfiltered samples may contain metals present as particulate matter, whereas filtered samples are representative of the more-mobile, dissolved metals. Filtered samples also may contain some colloidal particles that are fine enough to pass through the filter. Drinking water standards are based on unfiltered concentrations; however, differences in well construction and pumping practices between monitoring wells and water supply wells make it difficult to predict potential drinking water concentrations from monitoring well data when the metals are present as particulate matter. In general, filtered samples provide the best indication of groundwater contamination levels for chromium because unfiltered samples are subject to greater variability introduced by the sampling process. Chromium concentrations in filtered samples, which are considered to be representative of dissolved hexavalent chromium, will be used to describe the level of contamination in the discussion below.

Chromium in the 100 Areas. Chromium has been detected above the drinking water standard in the 100-B,C, 100-D, 100-H, 100-K, and 100-N Areas. Groundwater pump-and-treat systems continued to operate in 1998 to reduce the amount of hexavalent chromium entering the Columbia River at the 100-D, 100-H, and 100-K Areas. The purpose of the pump-and-treat systems is to prevent discharge of hexavalent chromium into the Columbia River at concentrations exceeding 11 μg/L, which is the EPA's standard for protection of freshwater aquatic life.

Chromium exceeded the drinking water standard from a filtered sample in the 100-B,C Area in 1998. The maximum concentration was 113 μg/L downgradient of former water treatment facilities, where sodium dichromate may have leaked from storage tanks and transfer facilities.

The chromium distribution in the 100-D Area is shown in Figure 6.1.28. An area of chromium concentrations greater than the drinking water standard extends from northeast to southwest across the 100-D Area near the Columbia River. The source of chromium in groundwater is sodium dichromate released to the ground at former facilities near D Reactor. Leakage from inactive retention basins and liquid waste disposal trenches north of D Reactor may also have contributed to the chromium plume. In 1998, the maximum chromium concentration from filtered samples was 2,200 μg/L in a well in the vicinity of a chromium hot spot in the southwestern portion of the 100-D Area. The source of this hot spot is unknown. In situ redox manipulation technology is currently being demonstrated in the hot spot area to address hexavalent chromium contamination in groundwater. This technology immobilizes hexavalent chromium by reducing the soluble chromate ion to highly insoluble chromium hydroxide or iron chromium hydroxide. In 1998, results of a

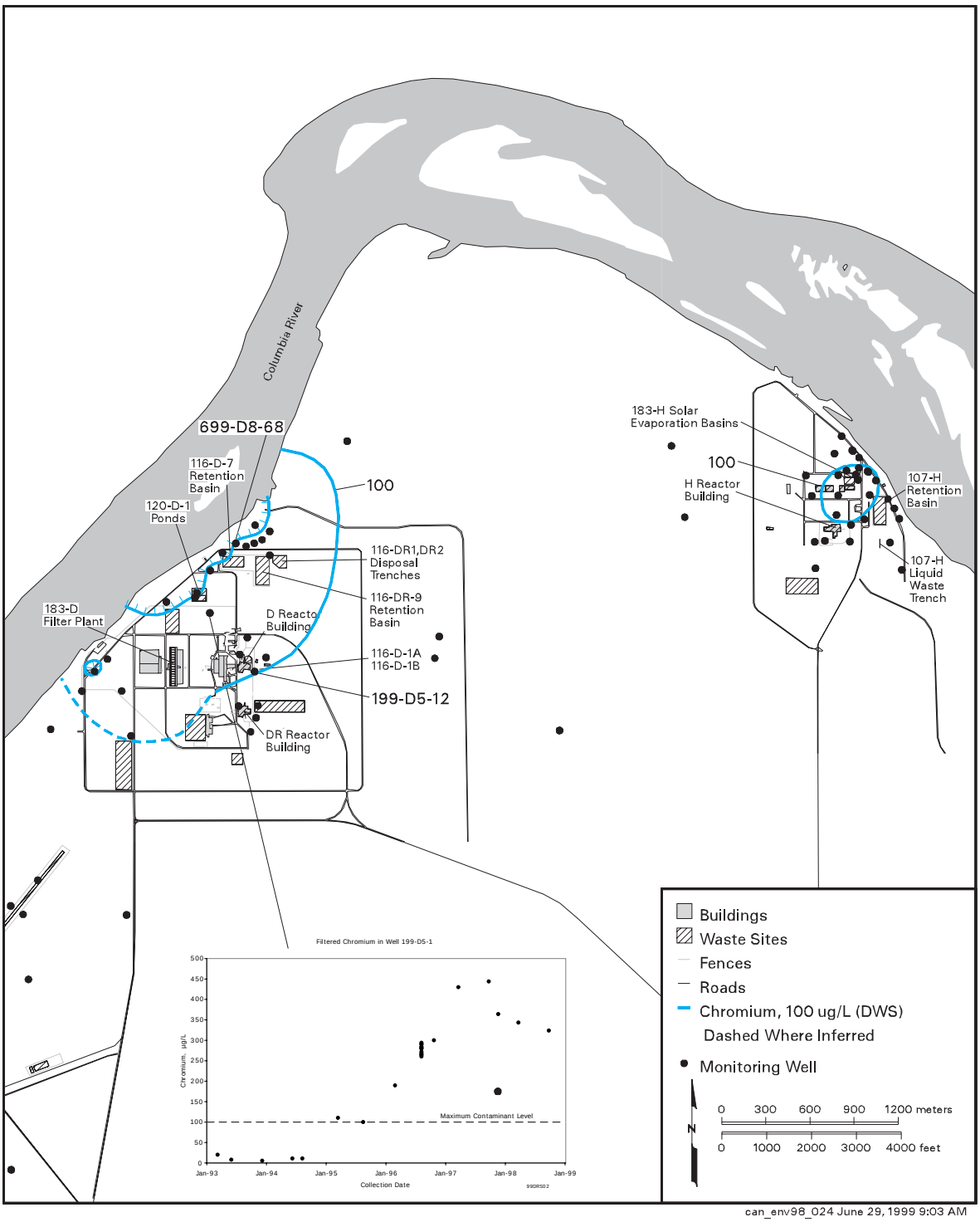


Figure 6.1.28. Average Filtered Chromium Concentrations in the 100-D and 100-H Areas, 1998, and Concentration Trends for Selected Wells

treatability study indicated that hexavalent chromium concentrations were decreased from ~1,000 μg/L to less than detection limits (7 μg/L) within the treatment zone. In the area near the inactive 120-D-1 Ponds, chromium concentrations increased in response to ceased discharges of noncontaminated water to the ponds in 1994, as shown by the trend plot for well 199-D5-13 in Figure 6.1.28. Chromium concentrations decreased in late 1997 through 1998.

Many samples from 100-H Area wells contained chromium at levels greater than the drinking water standard (see Figure 6.1.28). In 1998, the maximum chromium concentration from filtered samples collected from the shallow parts of the unconfined aquifer was 259 μg/L in a well near the former 183-H Solar Evaporation Basins. Chromium was also found at levels above the drinking water standard in one well monitoring the deeper part of the unconfined aquifer. Filtered samples from this well, located near the former 183-H Basins, contained 201 μg/L of chromium in 1998. Potential sources include past disposal of sodium dichromate near H Reactor, disposal to the inactive 107-H Liquid Waste Disposal Trench, and chromium in acid wastes stored in the former 183-H Basins (Peterson and Connelly 1992). Chromium was also detected above the drinking water standard in the 600 Area west of the 100-H Area. The maximum concentration in this area in 1998 was 102 μg/L. The primary sources of the chromium plume west of 100-H Area were former 100-D Area liquid waste disposal facilities. Effluent releases at the 100-D Area during operations produced groundwater mounding, which altered flow conditions. This contributed to the spreading of chromium contamination into the 600 Area.

A groundwater remediation pump-and-treat system to decrease the amount of hexavalent chromium entering the Columbia River from the aquifer continued to operate in the 100-D and 100-H Areas in 1998. Groundwater extracted from the 100-D Area wells downgradient of the inactive retention basins is piped to the 100-H Area for treatment. Groundwater extracted from the 100-D and 100-H Area wells is treated using ion-exchange technology and then reinjected into the aquifer in the southwestern part of the 100-H Area. Performance of the interim action to pump and treat has shown that hydraulic containment, resulting from the operation of the extraction wells, has reduced the amount of chromium entering the river from the aquifer in both the 100-D and 100-H Areas (DOE/RL-97-96, DOE/RL-99-13). By the end of December 1998, approximately 53 kg (116 lb) of chromium were removed from >401.5 million L (106.1 million gal) of groundwater extracted from these areas since pump-and-treat operations began in July 1997.

Chromium in the 100-K Area occurs in groundwater near or at levels greater than the drinking water standard (Figure 6.1.29). Two localized areas of chromium contamination occur near the KW Reactor and the water treatment basins southeast of the KE Reactor. The maximum concentration in 1998 was 443 μg/L near the KW Reactor. By late 1998, chromium concentrations reached a maximum of 249 μg/L in a well (199-K-36) adjacent to the 183-KE Water Treatment Basins and inactive sodium dichromate storage tanks. A much wider area of chromium contamination is found in the vicinity of the former 116-K-2 Liquid Waste Disposal Trench to the northeast. A pump-and-treat system for treating chromium in groundwater between the trench and the Columbia River, which began operating in October 1997, continued to operate in 1998. Groundwater extracted from a network of wells is treated using ion-exchange technology and then returned to the aquifer upgradient of the 116-K-2 Trench. By the end of December 1998, approximately 42 kg (93 lb) of chromium have been removed from >311 million L (82 million gal) of extracted groundwater (DOE/RL-99-13).

In the 100-N Area, chromium contamination is not widespread in groundwater. However, filtered samples in one well that monitors a locally confined

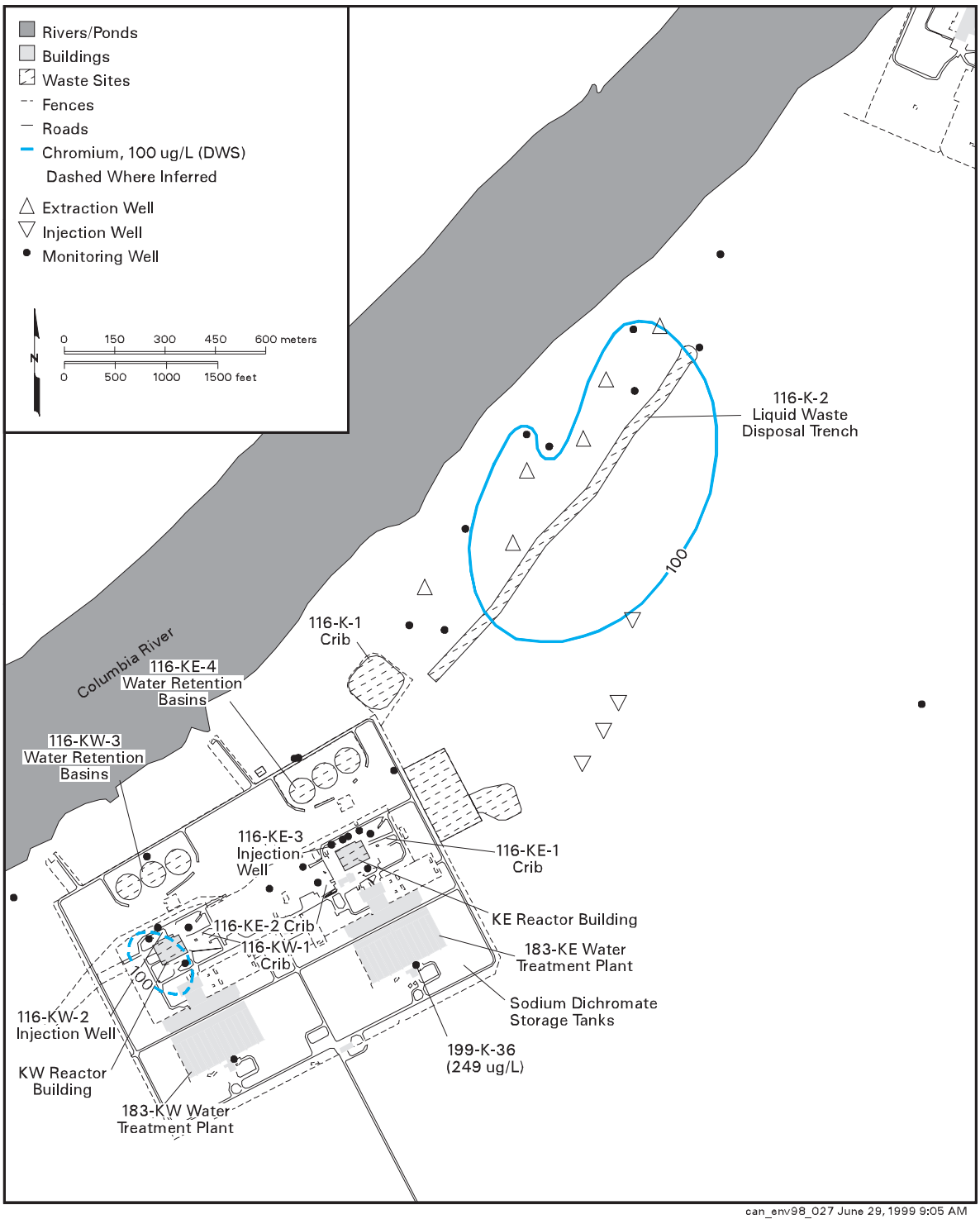


Figure 6.1.29. Average Filtered Chromium Concentrations in the 100-K Area, 1998

unit within the Ringold Formation have consistently shown concentrations greater than the drinking water standard northwest of the 1301-N Liquid Waste Disposal Facility. A filtered sample from a well upgradient of the inactive 1301-N facility contained a concentration of 124 μg/L, which exceeded the drinking water standard in this well for the first time. The source for the contamination at these locations is unknown.

Chromium in the 200 Areas. Chromium at concentrations greater than the drinking water standard in the 200-East Area was found in one well on the southern boundary of the A and AX Tank Farms. The maximum concentration detected in the sample was 2,820 μg/L. Concentrations in this well have been sporadic, and the source of the chromium is unknown.

Chromium contamination has been found at several locations in the 200-West Area. Areas where concentrations exceeded the drinking water standard in 1998 include the T, TX, and TY Tank Farms and 216-S-10 Pond. Filtered samples from a new well monitoring the TX and TY Tank Farms showed a maximum concentration of 180 μg/L, the highest filtered chromium concentration in the 200-West Area. The highest concentration found in the vicinity of T Tank Farm was 172 μg/L. The highest concentration near the former 216-S-10 Pond was 175 μg/L.

Chromium in Other Areas. Filtered chromium concentrations above the drinking water standard have been known to occur downgradient of the 200-West Area (located southwest of the 200-East Area). However, the sampling frequency of wells in this area was changed from annual to every 3 yr in 1998 because historical trends showed that chromium concentrations were steady in this area. The maximum concentration in this area in 1997 was 226 μg/L. The extent of chromium contamination in this area is poorly defined, and the source has not been determined.

Carbon Tetrachloride. The carbon tetrachloride contamination that occurs above the 5-μg/L drinking water standard in much of the 200-West Area represents one of the most significant contaminant plumes at the Hanford Site (Figure 6.1.30). The plume covers an area that is >10 km^2 (4 mi^2). However, the overall carbon tetrachloride distribution has changed slowly since the plume was first identified in 1987.

The bulk of the contamination is believed to be from waste disposal operations associated with the Plutonium Finishing Plant in the west-central part of the 200-West Area. Carbon tetrachloride was used as the carrier solvent for tributyl phosphate in the final purification of plutonium. Carbon tetrachloride was also used in the same facility as a nonflammable thinning agent while machining plutonium. A minor source of carbon tetrachloride is a former waste disposal crib near T Plant. Carbon tetrachloride is immiscible in water but exhibits a relatively high solubility (805,000 μg/L at 20°C [68°F]). Carbon tetrachloride has been found to have a relatively high degree of mobility in groundwater. Mobilization above the water table can also occur through vapor transport.

Wells in the vicinity of the Plutonium Finishing Plant showed the highest concentrations in the plume, with levels exceeding the drinking water standard by more than two orders of magnitude. The maximum concentration was near 7,000 μg/L in one pump-and-treat extraction well just north of the plant. Pump-and-treat operations, which began in 1994, have influenced the distribution of carbon tetrachloride. The plume center continues to move in a northerly and easterly direction toward the extraction wells, as evidenced by increased concentrations in several extraction and monitoring wells (DOE/RL-99-02). The extraction wells are located north and east of the Plutonium Finishing Plant. Carbon tetrachloride concentrations in the vicinity of the injection wells southwest of the plant continue to decline as a result of injection of the treated water. As of September

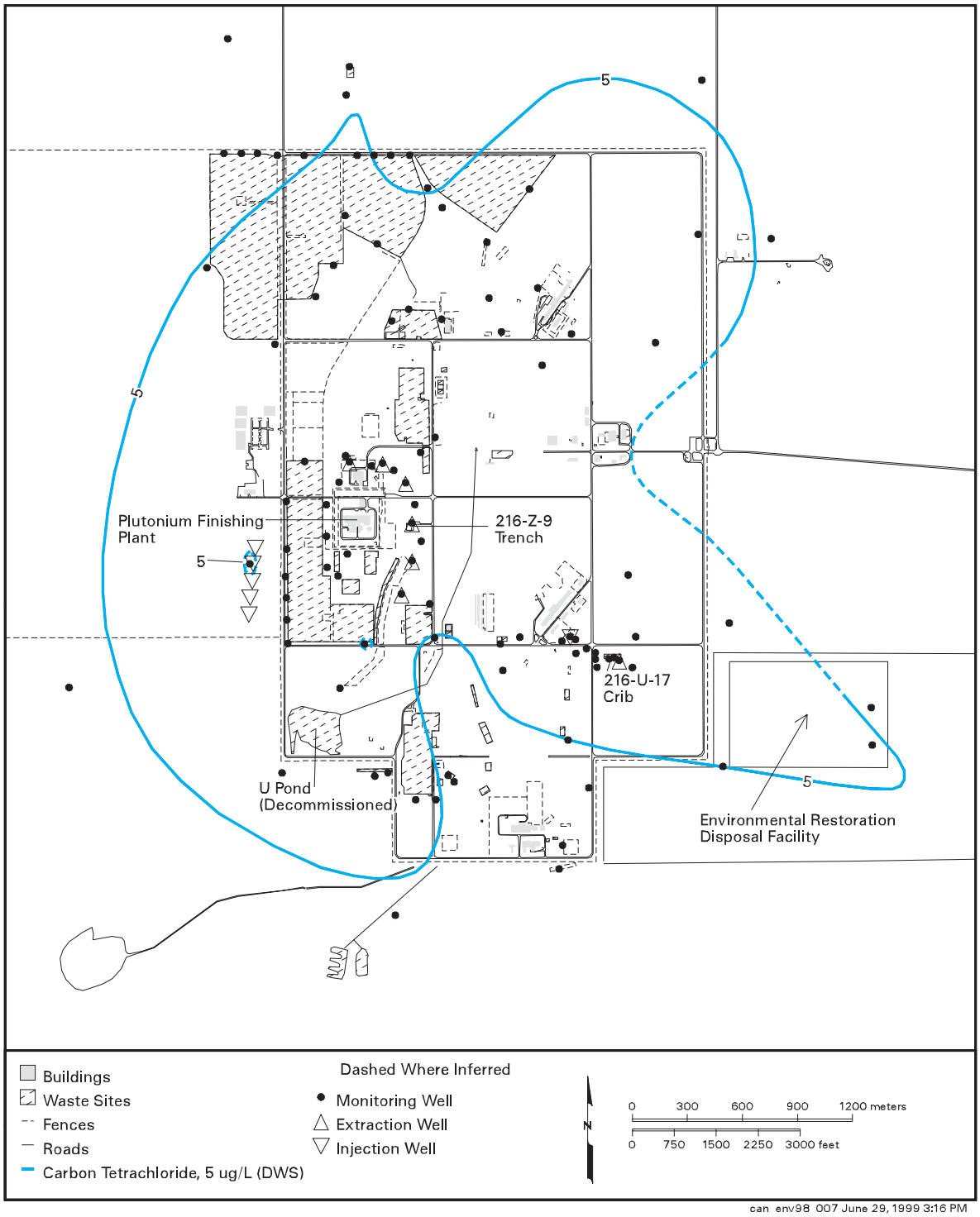


Figure 6.1.30. Average Carbon Tetrachloride Concentrations in the Unconfined Aquifer in the 200-West Area, 1998

1998, approximately 615 million L (162 million gal) of extracted groundwater have been treated, resulting in the removal of 2,099 kg (4,637 lb) of carbon tetrachloride (DOE/RL-99-02).

Near the 216-U-17 Crib in the southeastern part of the 200-West Area, the pump-and-treat system removed 13.8 kg (30.3 lb) of carbon tetrachloride from approximately 338 million L (89 million gal) of extracted groundwater as of September 1998 (DOE/RL-99-02).

The extent of carbon tetrachloride contamination in deeper parts of the aquifer is uncertain because of the limited amount of concentration data from depths below the water table. The limited amount of data indicates that the concentrations are highest at the top of the aquifer and decline with depth at most locations within the plume. In 1998, carbon tetrachloride was found at a level of 12 μg/L at a depth of ~58 m (190 ft) below the water table near the Plutonium Finishing Plant.

Changes in groundwater flow since decommissioning U Pond may be influencing the plume configuration and the concentrations at particular locations. Another potential influence is the continued spreading of carbon tetrachloride above the water table, in either the liquid or vapor phase. Free-phase, liquid, carbon tetrachloride above and possibly below the water table provides a continuing source of contamination. Therefore, lateral expansion of the carbon tetrachloride plume is expected to continue.

Chloroform. A chloroform plume appears to be associated with, but not exactly coincident with, the carbon tetrachloride plume in the 200-West Area (Figure 6.1.31). The highest chloroform concentrations were measured in the vicinity of the Plutonium Finishing Plant, where the maximum level was 120 μg/L. The drinking water standard for chloroform is 100 μg/L (total trihalomethanes), which is 20 times higher than that for carbon tetrachloride. The origin of chloroform is unknown, but is suspected to be a degradation product of carbon tetrachloride or an anaerobic degradation product associated with septic drain fields.

Trichloroethylene. A commonly used organic solvent, trichloroethylene has a drinking water standard of 5 μg/L. In 1998, trichloroethylene was detected at levels greater than the drinking water standard in some wells in the 100, 200, 300, and 600 Areas. The most widespread area of contamination occurred in the 200-West Area.

Trichloroethylene in the 100 Areas. Trichloroethylene was detected at levels greater than the drinking water standard in the southwestern corner of the 100-F Area and in the adjacent 600 Area. The maximum concentration detected in this area was 18 μg/L in the adjacent 600 Area. No specific sources of this contamination have been identified.

In the 100-K Area, two wells sampled contained trichloroethylene at levels above the drinking water standard, representing a localized area of contamination near the KW Reactor complex. The maximum concentration was 24 μg/L in monitoring well 199-K-106A.

Trichloroethylene in the 200 Areas. Trichloroethylene was detected at levels greater than the drinking water standard in several parts of the 200-West Area (Figure 6.1.32). The most significant area extends from the Plutonium Finishing Plant to the west of T Plant and past the northern boundary of the 200-West Area. The source of the contamination is presumably past disposal in these plant areas. The highest concentration was 23 μg/L northeast of the Plutonium Finishing Plant. A smaller, isolated area of contamination occurs downgradient of the U Plant cribs, where the maximum concentration was 15 μg/L.

Trichloroethylene in the 300 Area. Trichloroethylene was detected at one well in 1998 in the 300 Area at concentrations above the drinking water

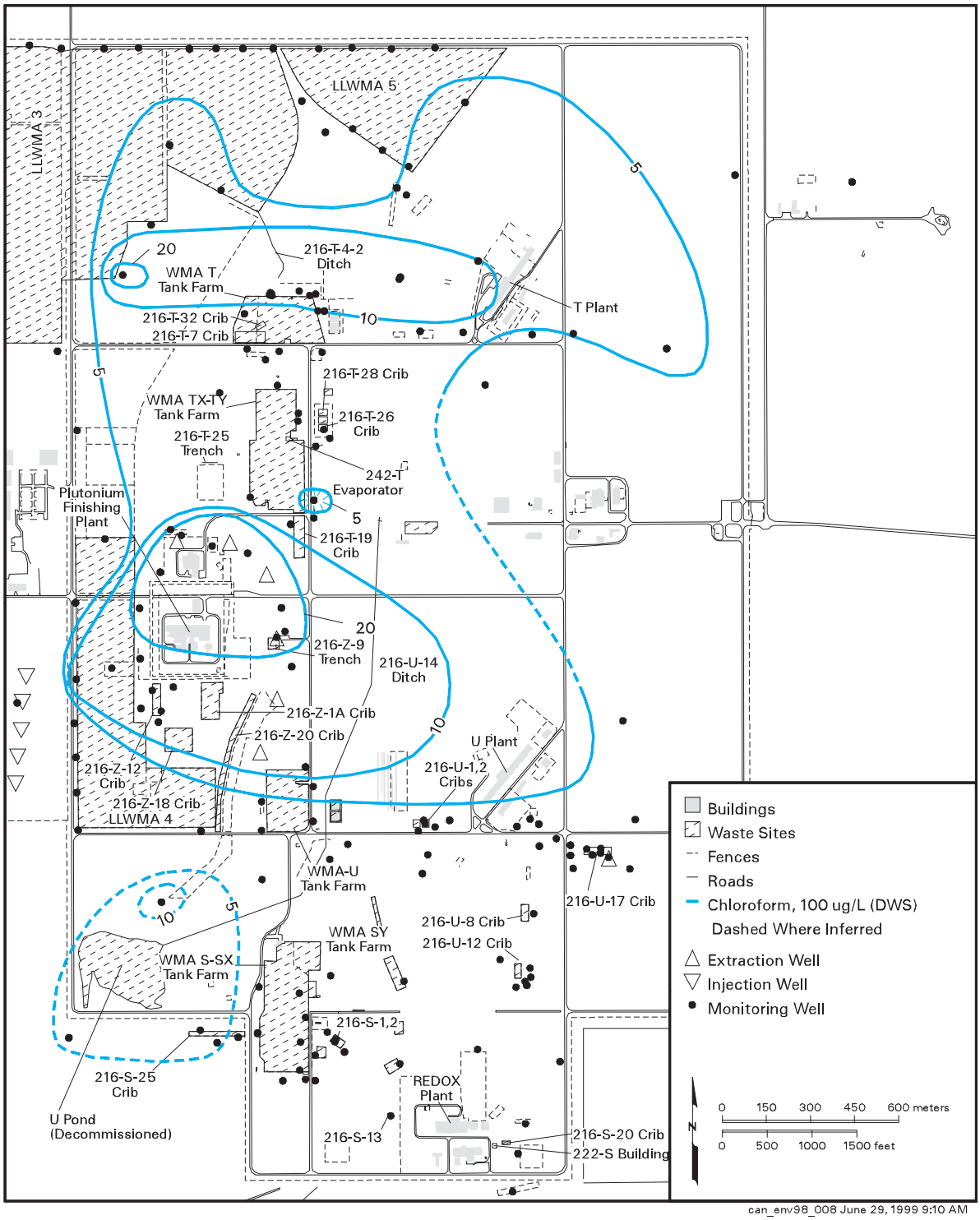


Figure 6.1.31. Average Chloroform Concentrations in the Unconfined Aquifer in the 200-West Area, 1998

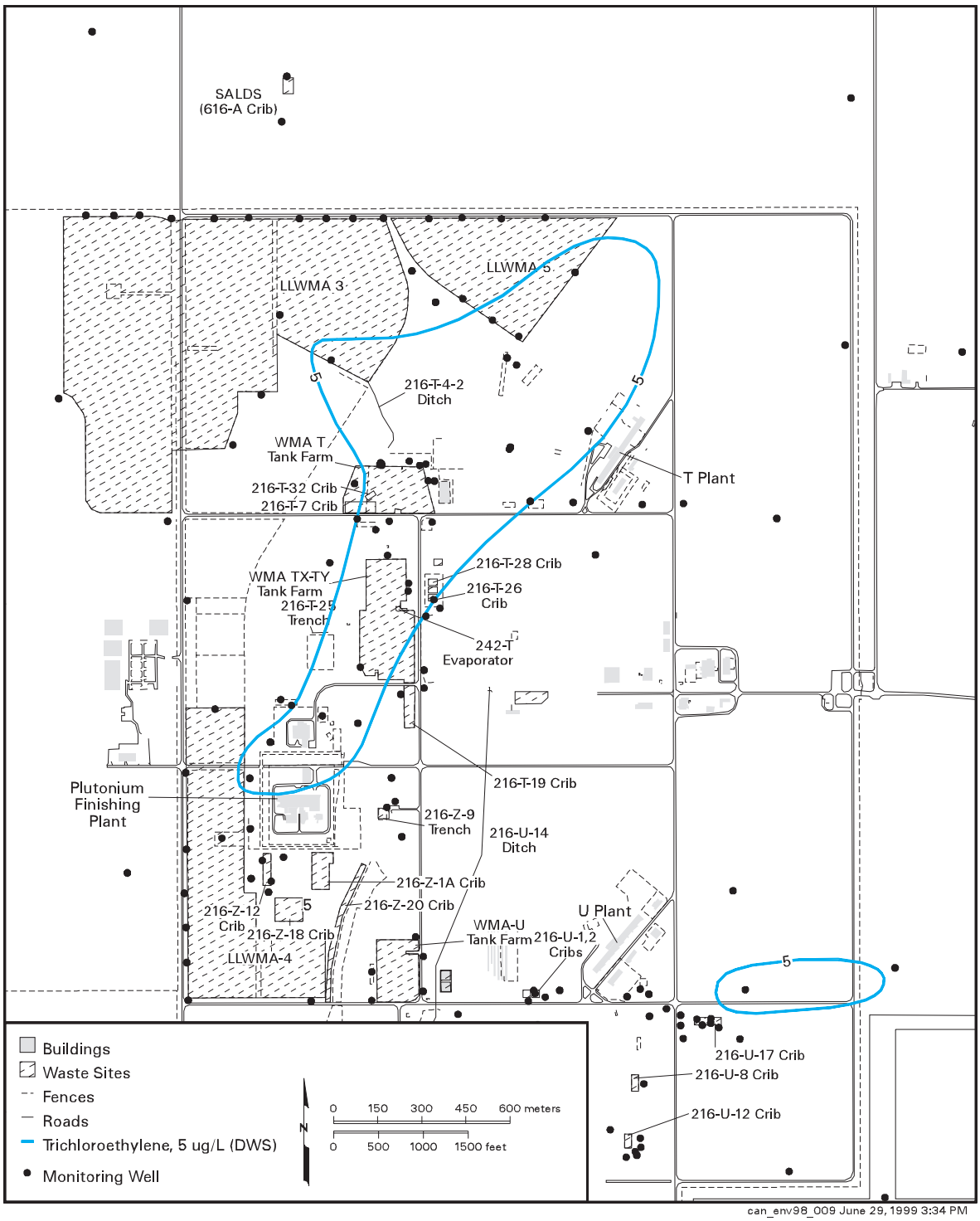


Figure 6.1.32. Average Trichloroethylene Concentrations in the Unconfined Aquifer in the 200-West Area, 1998

standard. The maximum concentration was 8 μg/L at well 399-1-16B. This well monitors the base of the unconfined aquifer downgradient of the former 316-5 process trenches.

Trichloroethylene in the 600 Area. Trichloroethylene was found at levels above the drinking water standard in a number of wells in the vicinity of the former Horn Rapids Landfill in the southern part of the site (Richland North Area). This contamination forms an elongated plume that extends from an area just south of the landfill to near the southwestern corner of the 300 Area and has an origin off the Hanford Site (Figure 6.1.33). The maximum contamination detected in this plume in 1998 was approximately 10 μg/L on the northeastern side of the landfill.

Tetrachloroethylene. Also referred to as perchloroethylene (or PCE), tetrachloroethylene was detected at levels above the 5-μg/L drinking water standard in the 300 Area during 1998. In the 300 Area, a new plume of tetrachloroethylene was discovered between the former process trenches and ponds and the Columbia River during 1998 (Figure 6.1.34). The maximum concentration detected was 38 μg/L near the southern end of the process trenches. However, by the end of 1998, concentrations decreased to levels near the drinking water standard. One possible source of the contamination was vadose zone residuals that were mobilized by the high-river levels in 1996 and 1997. Tetrachloroethylene was commonly used as a degreasing solvent.

cis-1,2-Dichloroethylene. Concentrations of cis-1,2-dichloroethylene, a biodegradation product of trichloroethylene, remain elevated in well 399-1-16B, located near the former process trenches and ponds in the 300 Area. This well is completed in the deeper part of the unconfined aquifer and is the only well on the site where this constituent is found at levels above the 70-μg/L drinking water standard. In 1998, a maximum of 180 μg/L was detected in this well.

Cyanide. Waste fractionation activities performed in the late 1950s used large quantities of sodium and nickel ferrocyanide to recover cesium-137. Large volumes of aqueous supernatant waste containing excess ferrocyanide were disposed to the ground in both the northern and southern portions of the 200-East Area. Smaller quantities were also disposed to former cribs in the 200-West Area. Procedures used to analyze for cyanide do not distinguish between ferrocyanide and free cyanide. Cyanide results reported here are, thus, normally assumed to be residual ferrocyanide associated with the discharges from the waste fractionation activities performed >30 yr ago. A chemical speciation study performed in 1988 indicated that approximately one-third of the cyanide in groundwater is present as free cyanide and the rest may be present as ferrocyanide (Section 4.1 in PNL-6886 and Section 3.2.2 in PNL-7120). The drinking water standard for cyanide is 200 μg/L.

The highest cyanide levels were detected in samples collected from wells in the northwestern part of the 200-East Area and in the 600 Area north of the 200-East Area. Only samples collected from one well near the inactive BY Cribs showed concentrations above the drinking water standard in 1998. The maximum concentration (347 μg/L) was a significant increase compared to levels in 1997 and correlates with cobalt-60 levels. Wells containing cyanide often contain several radionuclides, including cobalt-60. Although cobalt-60 is normally immobile in the subsurface, it appears to be chemically complexed by cyanide or ferrocyanide. The complexed chemical species is more soluble and more mobile in groundwater.

Fluoride. At this time, fluoride has a primary drinking water standard of 4 mg/L and a secondary standard of 2 mg/L. Secondary standards are based primarily on aesthetic rather than health considerations. Fluoride was detected above the primary drinking water standard at three wells near T Tank Farm in the 200-West Area in 1998. The new well

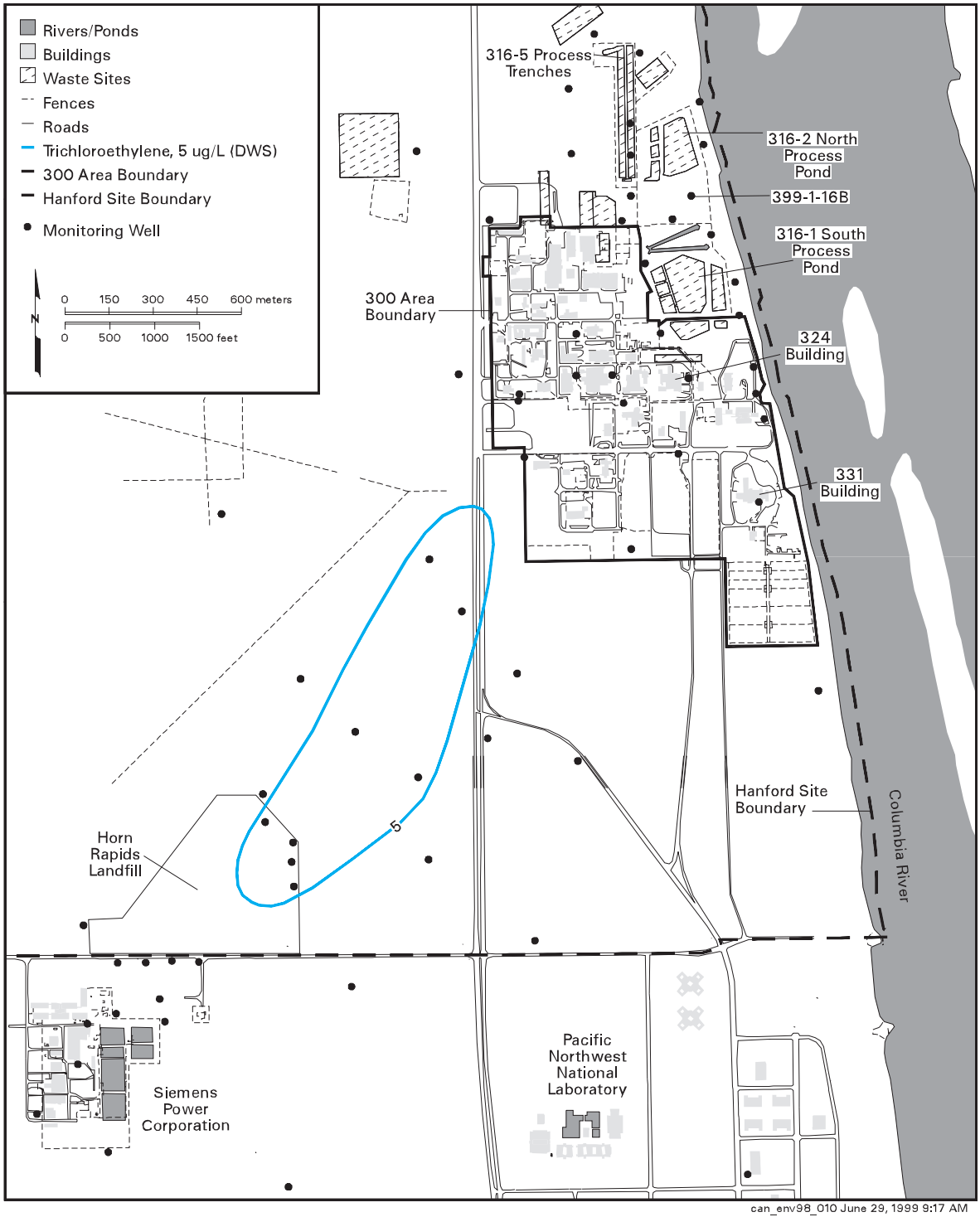


Figure 6.1.33. Average Trichloroethylene Concentrations in the Vicinity of the Former Horn Rapids Landfill and Richland North Area, 1998

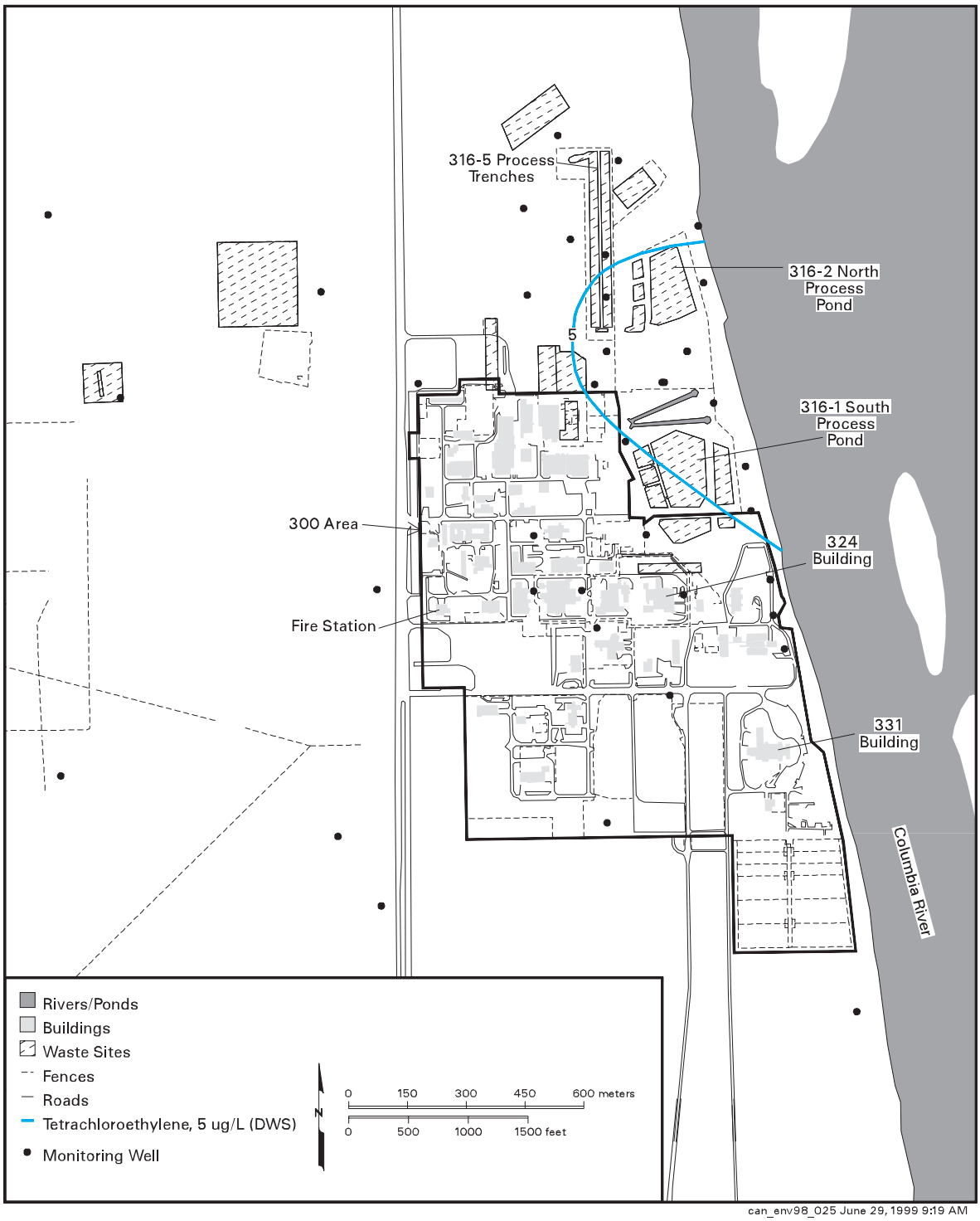


Figure 6.1.34. Average Tetrachloroethylene Concentrations in the 300 Area, 1998

(299-W10-24) showed a maximum fluoride concentration of 5 mg/L. A few wells near the T Tank Farm showed concentrations above the secondary standard. Aluminum fluoride nitrate used in the past 200-West Area processes is the probable source of the fluoride contamination.

6.1.6.3 Radiological and Chemical Monitoring Results for the Basalt-Confined Aquifer

Aquifers confined below the uppermost basalt layers show much less impact from Hanford Site contamination than the unconfined aquifer system within the overlying sediments. The minor contamination found in the basalt-confined aquifers may be attributed to several factors. These factors include areas where the confining layers of basalt have been eroded away, areas where disposal of large amounts of water resulted in downward gradients, and areas where wells penetrating to the confined aquifers provided pathways for contaminant migration. These factors produced intercommunication between the aquifers, meaning they permitted the flow of groundwater from the unconfined aquifer to the underlying confined aquifer, thereby increasing the potential to spread contamination. Because fewer wells are available to evaluate contamination in the confined aquifer, it is important to consider contamination in the confined aquifer even where the levels are well below drinking water standards. The distribution of tritium and other detected contaminants in the upper basalt-confined aquifer are shown in Figure 6.1.35.

Intercommunication between the unconfined and basalt-confined aquifers in the vicinity of the northern part of the 200-East Area has been identified previously in RHO-BWI-ST-5 and RHO-RE-ST-12 P. The hydrochemical and hydrogeologic conditions within the upper basalt-confined aquifer system and the potential for offsite migration of contaminants through confined aquifer pathways were evaluated in PNL-10817.

Several confined aquifer wells north and east of the 200-East Area that show evidence of intercommunication with the overlying unconfined aquifer were identified in PNL-10817. Intercommunication between the unconfined and confined aquifers in the area north and east of the 200-East Area has been attributed to erosion of the upper Saddle Mountains Basalt and downward vertical gradients that result from groundwater mounding associated with waste disposal. Groundwater chemical data from most confined aquifer wells in other areas of the Hanford Site do not exhibit evidence of contamination, with the exception of wells that were previously open to both the unconfined and confined aquifers, thus providing conduits for the downward transport of contamination.

Results of the 1995 sampling and analyses of groundwater from the upper basalt-confined aquifer indicated only a few areas of concern that warranted continued annual monitoring. Consequently, the number of wells sampled during 1998 was reduced to include only those with groundwater contamination or those downgradient from areas with historical indications of contamination. Prominent analytical results and trends arising from 1998 sampling are discussed below. The locations of wells used for monitoring confined aquifer groundwater chemistry were given in Figure 6.1.11.

Contamination has also been identified in the confined aquifer in the northern part of the 200-East Area and adjacent parts of the 600 Area. The highest levels of contamination detected in the confined aquifer in this vicinity were in well 299-E33-12. Contamination in this well is attributed to migration of high-salt waste down the borehole during construction when it was open to both the unconfined and confined aquifers (RHO-RE-ST-12 P). Contaminant concentrations continue to be elevated in this well. During 1998, technetium-99 was detected in well 299-E33-12 at 1,810 pCi/L, which is above the 900-pCi/L interim drinking water standard. Cobalt-60 was detected in this well (21.8 pCi/L) in 1998.

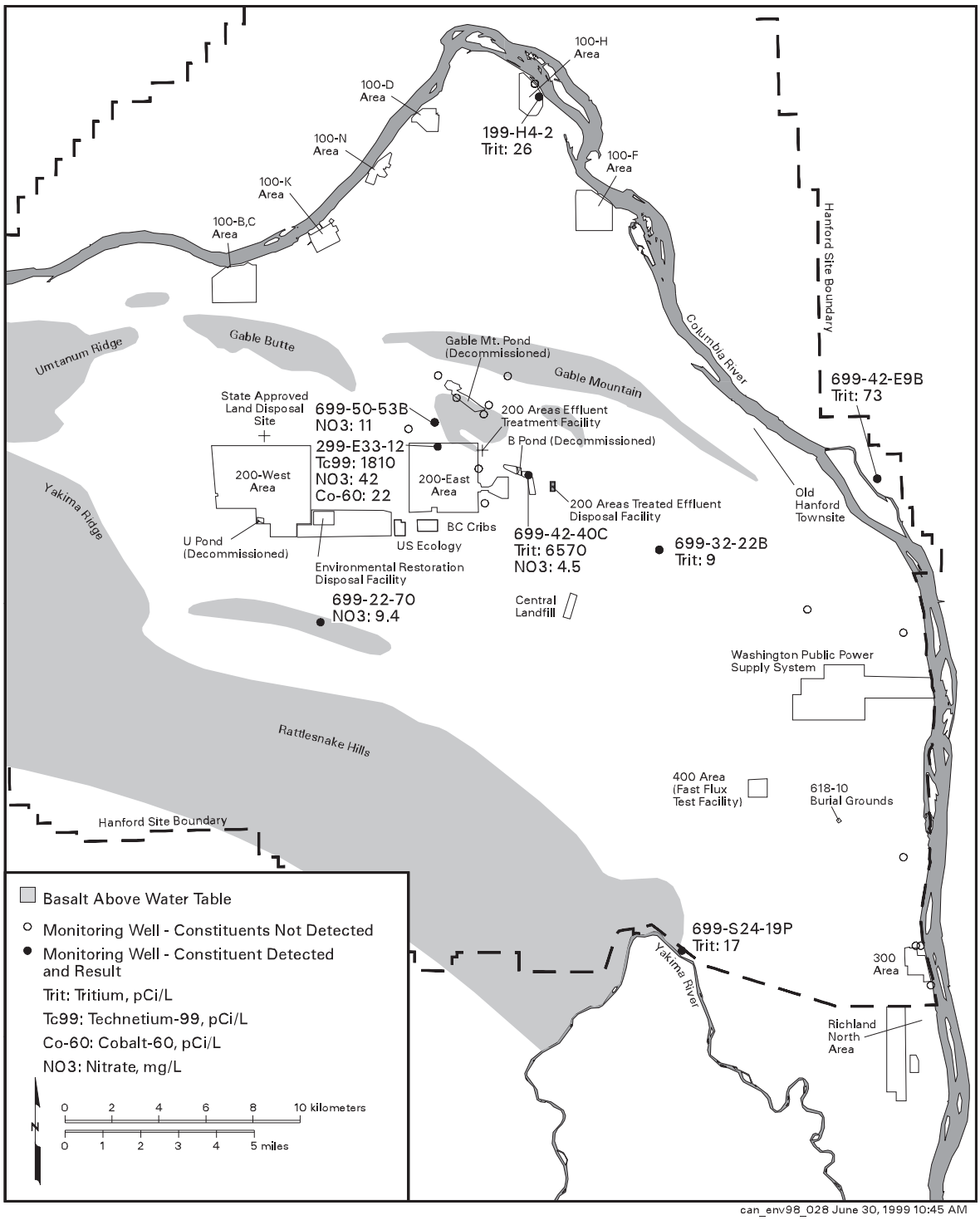


Figure 6.1.35. Tritium and Other Contaminants Detected in Confined Aquifer Wells, 1998

Well 699-42-40C monitors the confined aquifer adjacent to the former B Pond. Tritium in this well was 6,570 pCi/L, the highest level observed in the confined aquifer in 1998. Tritium in this well is believed to have originated from downward migration from the overlying, unconfined aquifer.

Wells are completed in the basalt-confined aquifer near the base of the Rattlesnake Hills in an area where pervasive downward flow from the unconfined aquifer recharges the upper portion of the confined aquifer (PNL-10817). Samples from one well contained up to 9.4 mg/L of nitrate in 1998, well below the 45-mg/L drinking water standard. Nitrate in the overlying unconfined aquifer in the Dry Creek Valley area and in wells near the base of the Rattlesnake Hills may result from agricultural sources to the south and west and is not believed to originate from sources on the Hanford Site.

6.1.7 RCRA Summary

More than 60 treatment, storage, and disposal units are recognized under the RCRA permit for the Hanford Site. Of these, 26 required groundwater monitoring during 1998. Locations of these groundwater monitoring sites were given in Figure 6.1.12. This section provides a summary of groundwater monitoring activities and results for these sites. Additional information, including RCRA groundwater monitoring and complete listings of radioactive and chemical constituents measured in monitoring wells from October 1997 through September 1998, is available in PNNL-12086. Any significant changes that occurred from October through December 1998 are noted below.

RCRA groundwater monitoring is conducted under one of three phases: 1) indicator parameter/detection, 2) groundwater quality assessment/compliance, or 3) corrective action. Initially, a detection program is developed to monitor the impact of facility operations on groundwater. During the indicator parameter/detection phase, groundwater parameters established for the particular site are measured in wells upgradient and downgradient from the site. Statistical tests are applied to the monitoring results to calculate "critical mean" values for each monitoring parameter. These values represent the background water quality for the site. Subsequent monitoring data are compared to the critical mean values to determine if there has been a statistically significant increase (or pH decrease) in the concentrations of key indicator parameters or dangerous waste constituents in the groundwater. The statistical methods used to calculate critical means and compare with monitoring data are described in Appendix B in PNNL-12086. If a statistically significant change from the "critical mean" is observed, then a groundwater quality assessment/compliance phase of monitoring and investigation is initiated. During this phase, groundwater monitoring is designed to determine if groundwater protection standards have been exceeded. If the source of the contaminants is determined to be the treatment, storage, and disposal unit and concentrations exceed maximum contaminant levels defined in the monitoring plan or permit, then the Washington State Department of Ecology may require corrective action to reduce the contaminant hazards to the public and environment. Groundwater monitoring during the corrective action phase is designed to assess the effectiveness of the corrective action. Table 2.2.2 in Section 2.2, "Compliance Status," listed the phase pertaining to each of the RCRA groundwater monitoring projects at the end of 1998.

6.1.7.1 100 Areas Facilities

120-D-1 Ponds. These ponds were constructed in 1977 for disposal of nonradioactive effluent derived from operating facilities in the 100-D,DR Area. This facility is located in the former 188-D Ash

Disposal Basin and includes settling and percolation ponds separated by a dike. Effluent to the ponds originated from two sources: the 183-D Filter Plant and the 189-D Building engineering testing laboratories. Some past discharges contained hydrochloric acid, sodium hydroxide, and sulfuric acid. Before 1986, the effluent may have had a >12.5 or <2.0 pH and, thus, may have been dangerous waste. There was also a potential for up to 2.3 kg (5 lb) of mercury to have been discharged to the ponds. Between 1986 and 1994, the effluent discharged to the ponds included chlorine and flocculating agents such as aluminum sulfate. Effluent discharge to the ponds ceased in 1994. Contaminated soils were removed from the ponds in 1996.

Recharge from the ponds diluted ambient groundwater, but did not degrade groundwater quality. In 1998, specific conductance, pH, total organic carbon, and total organic halide in downgradient wells continued to be below the background critical mean values. Mercury is the only listed waste that may have been discharged to these ponds but it has never been detected in any of the downgradient monitoring wells. The 100-D Ponds will be clean-closed when modification D of the RCRA permit is signed in 1999, and no further groundwater monitoring will be required. Until then, the site remains in indicator parameter monitoring.

183-H Solar Evaporation Basins. This facility, now remediated, consisted of four separate concrete basins surrounded by an earthen berm. Between 1973 and 1985, the basins were used to store liquid waste, primarily from nuclear fuel fabrication activities conducted in the 300 Area. Volume reduction occurred by solar evaporation. The waste was predominantly acid etch solution that had been neutralized with sodium hydroxide before being discharged into the basins. The solutions included chromic, hydrofluoric, nitric, and sulfuric acids and also contained various metallic and radioactive constituents. Groundwater in the vicinity of these basins is characterized by elevated levels of chromium, nitrate, technetium-99, and uranium. All of these constituents were present in waste discharged to the basins when they were in use.

The basins are subject to final-status monitoring. Concentration limits for chromium, nitrate, technetium-99, and uranium were exceeded in one or more downgradient wells in 1996 and 1997, and a corrective-action groundwater monitoring plan was released in 1997 (PNNL-11573). The monitoring plan was implemented in early 1998 after the corrective-action plan was incorporated into a revision of the RCRA permit. The monitoring plan takes into account the effects of a pump-and-treat system that began operation in 1997. Four wells are sampled annually for the constituents of concern to monitor concentration trends. Although the concentrations decreased several orders of magnitude in this area since the basins ceased operation, nitrate, chromium, and uranium remained above their respective drinking water standards in 1998.

1301-N and 1325-N Liquid Waste Disposal Facilities. These facilities contaminated groundwater with radionuclides, most notably strontium-90 and tritium, as discussed in Section 6.1.6.1, "Radiological Monitoring Results for the Unconfined Aquifer." A pump-and-treat system is active as a CERCLA interim action to reduce the amount of strontium-90 flowing into the river at the 100-N Area. RCRA monitoring focuses on the hazardous (nonradioactive) constituents discharged to the facilities.

The 1301-N facility was the primary liquid waste disposal site for N Reactor from 1963 until 1985. Discharges were primarily radioactive fission and activation products. Minor amounts of dangerous waste and other constituents may also have been discharged, including ammonium hydroxide, cadmium, diethylthiourea, lead, morpholine, phosphoric acid, and sodium dichromate. The facility consists of a concrete basin with an unlined, zigzagging extension trench, covered with concrete panels.

The 1325-N facility was constructed in 1983 and also received effluent from N Reactor. In 1985, discharge to 1301-N ceased, and all effluent was sent to 1325-N. All discharge to 1325-N ceased in late 1991. The facility consists of a concrete basin with an unlined extension trench, covered with concrete panels.

Total organic carbon (the indicator parameter) exceeded the critical mean value at 1301-N downgradient well 199-N-3 in September 1998. The well was resampled and the value was verified. However, no organic constituents of concern were identified in 1301-N waste or sediments (DOE/RL-96-39), and the contamination is believed to have originated at one of several petroleum waste sites nearby (DOE/RL-95-111). The Washington State Department of Ecology was notified of the exceedance and its probable cause, and the site remains in a detection monitoring program. No other indicator parameters exceeded critical mean values at the 1301-N or 1325-N facilities. Groundwater at these facilities is also analyzed for other constituents that were discharged to them, including cadmium, chromium, lead, nitrate, and phosphate. Cadmium, chromium, lead, and phosphate were not detected in groundwater at these facilities in significant concentrations; however, nitrate continued to be detected at levels greater than the EPA maximum contaminant level in 1998, but the sources are uncertain.

1324-N and 1324-NA Ponds. The 1324-N Pond was a treatment facility that was in service from May 1986 to November 1988. This facility is a double-lined pond that was used for neutralizing high- and low-pH waste from a demineralization plant. The 1324-NA Pond is unlined and was used for treating waste from August 1977 to May 1986 and for disposing of treated waste from May 1986 to August 1990. The effluent to both facilities contained sulfuric acid and sodium hydroxide, and the pH was occasionally high or low enough to classify the effluent as a dangerous waste.

Specific conductance measured in wells downgradient from these ponds remained higher than the background critical mean value in 1998. This indicator parameter is high because the 1324-NA Pond introduced nondangerous constituents (e.g., sodium, sulfate) to groundwater. Total organic carbon was detected above the background critical mean value in one downgradient well in September 1997, and the value was confirmed in January 1998. No organic contaminants were present in the waste discharged to the facility (DOE/RL-96-39), and the Washington State Department of Ecology agreed that a groundwater quality assessment is not required. The contamination is believed to have originated at one of several petroleum waste sites nearby. Downgradient measurements of pH and total organic halide were below critical mean values.

6.1.7.2 200 Areas Single-Shell Tank Farms

Single-shell tanks are located in the A, AX, B, BX, BY, C, S, SX, T, TX, TY, and U Tank Farms, which have been designated as parts of RCRA Waste Management Areas A-AX, B-BX-BY, C, S-SX, T, TX-TY, and U, respectively. Waste Management Areas A-AX, B-BX-BY, and C are located in the 200-East Area; Waste Management Areas S-SX, T, TX-TY, and U are in the 200-West Area. Each waste management area includes tanks and associated ancillary systems (e.g., pipelines). The single-shell tanks store a mixture of dangerous chemical and radioactive wastes generated by reprocessing fuel irradiated in Hanford Site reactors. The single-shell tanks received mixtures of organic and inorganic liquids that contain radionuclides, solvents, and metals that were originally discharged to the tanks as alkaline slurries. Subsequent waste management operations have combined waste streams from different processes. In many tanks, wastes have been concentrated by removing water through evaporation.

Waste Management Area A-AX. Critical mean values for pH, specific conductance, total

organic carbon, and total organic halide (the indicator parameters) were not exceeded during 1998. Iodine-129 exceeded the 1-pCi/L drinking water standard in the monitoring wells because of a plume extending through this area from other sources. Chromium, manganese, and nickel exceeded drinking water standards in one of the network wells, and may be related to corrosion of the well screen.

Waste Management Area B-BX-BY. The results of the first phase of a groundwater quality assessment program were published in 1998 (PNNL-11826). It was concluded that the waste management area was most likely the cause of the elevated specific conductance that had triggered the assessment.

There appear to be two centers of technetium-99 contamination near the waste management area. Levels continued to exceed the 900-pCi/L interim drinking water standard in 1998 in several wells. This contamination was discussed in Section 6.1.6.1, "Radiological Monitoring Results for the Unconfined Aquifer," and its distribution was shown in Figure 6.1.21.

Nitrate concentrations continued to rise across the waste management area and exceeded the 45-mg/L drinking water standard in most of the monitoring network (see Section 6.1.6.1, "Radiological Monitoring Results for the Unconfined Aquifer"). There are two local centers of nitrate contamination that approximately correspond with the technetium-99 distribution.

Uranium concentrations exceeded the 20-mg/L proposed drinking water standard in four wells, but its source is not known. In late 1997 and early 1998, two high, rapid spikes of uranium were observed in one well (299-E33-41). Similar spikes in technetium-99 were observed in this well in 1997.

One new monitoring well was installed in 1998 to support the assessment program.

Waste Management Area C. Critical mean values for pH, specific conductance, total organic carbon, and total organic halide (the indicator parameters) were not exceeded during 1998. Iodine-129 showed levels above the 1-pCi/L drinking water standard in the monitoring wells because of a plume extending through this area from other sources.

Waste Management Area S-SX. The results of the first phase of a groundwater quality assessment program were released in 1998 and showed that the S and SX Tank Farms contributed to groundwater contamination (PNNL-11810). A second phase assessment is being conducted to determine the nature, extent, and source(s) of groundwater contamination attributed to Waste Management Area S-SX.

Mobile contaminants from the waste management area include chromium, nitrate, and technetium-99. All of these constituents were highest in well 299-W22-46 in 1998. Lower, but sharply increasing, levels of contaminants were observed in well 299-W22-45. Past spills or leaks from transfer lines or diversion boxes are potential sources of this contamination.

Waste Management Areas T and TX-TY. The results of the first phase of assessment monitoring were released in 1998 (PNNL-11809). There is evidence that Waste Management Area T has contaminated groundwater in well 299-W11-27. The source of contamination at Waste management Area TX-TY could not be determined, but a source within the waste management area could not be ruled out, so assessment will continue.

Specific conductance in Waste Management Area T well 299-W11-27 has declined slowly since a peak in 1996. This pulse of specific conductance was caused by increases in calcium, magnesium, nitrate, and sulfate and was accompanied by increases in chromium, cobalt-60, technetium-99, and tritium. Technetium-99 is the major contaminant present, reaching a peak in 1997 (21,700 pCi/L) and declining in 1998 (average = 7,390 pCi/L). The contaminants

affecting groundwater quality in well 299-W11-27 represent a very narrow plume, indicating a nearby source.

Specific conductance in Waste Management Area TX-TY well 299-W10-17 remained elevated in 1998 and is principally a result of elevated nitrate and sodium. Gross beta, nitrate, and tritium exceeded their drinking water standards during the year and represent a regional contaminant plume. Specific conductance also was elevated in well 299-W14-12 in 1998. The high specific conductance is a result of elevated calcium, magnesium, nitrate, and sulfate and is distinctly different from the regional sodium/nitrate signature.

Monitoring wells for these waste management areas are rapidly going dry because of a declining water table. Two new wells were installed in 1998 at Waste Management Area T to replace those that were dry. Four new wells were drilled at Waste Management Area TX-TY.

Waste Management Area U. This waste management area is under a detection-level monitoring program. Three indicator parameters (pH, specific conductance, and total organic carbon) remained below their background critical mean values. Total organic halides exceeded the critical mean value in well 299-W19-31 as a result of carbon tetrachloride contamination flowing into the area from upgradient sources. The Washington State Department of Ecology was informed of the exceedance and its source, and the waste management area remains in a detection monitoring program.

Technetium-99 remained slightly elevated in downgradient wells. Levels are below the interim drinking water standard but higher than upgradient wells. The highest value was in well 299-W19-31, where the annual average was 320 pCi/L.

Two new wells were installed in 1998 to replace wells that are nearly dry because of the declining water table.

6.1.7.3 200 Areas Liquid Effluent Disposal Facilities

216-A-10, 216-A-36B, and 216-A-37-1 Cribs. These inactive cribs received liquid waste from the Plutonium-Uranium Extraction Plant. The waste stream at the 216-A-10 Crib was characteristically acidic and contained concentrated salts, hydrocarbon compounds, organic complexants, plutonium, uranium, and other radionuclides. The 216-A-36B Crib received ammonia scrubber distillate from nuclear fuel decladding operations, in which zirconium cladding was removed from irradiated fuel by boiling in a solution of ammonium fluoride and ammonium nitrate. Other waste stream constituents included tritium, cobalt-60, strontium-90, ruthenium-106, iodine-129, cesium-137, and uranium. The 216-A-37-1 Crib received process condensate from the 242-A Evaporator. The process condensate contained radionuclides, spent halogenated and nonhalogenated solvents, and ammonia. The radionuclides included cobalt-60, strontium-90, ruthenium-106, cesium-137, uranium, and plutonium.

These three cribs are monitored as a single waste management area under an assessment program because they have similar hydrogeology and waste constituents. The cribs have contributed to the large nitrate, iodine-129, and tritium plumes downgradient of the 200-East Area (see Section 6.1.6.1, "Radiological Monitoring Results for the Unconfined Aquifer"). These constituents remained above drinking water standards in 1998. Strontium-90 also exceeded the interim drinking water standard in well 299-E17-14, adjacent to the 216-A-36B crib, with an annual average of 16 pCi/L.

216-A-29 Ditch. This is an inactive earthen ditch approximately 2 km (1.2 mi) long that conveyed Plutonium-Uranium Extraction Plant chemical waste to the 216-B-3 Pond from 1955 to 1986. The ditch received effluents that contained dangerous

chemical and radioactive contaminants. Of primary concern for RCRA regulations were discharges of sodium hydroxide and sulfuric acid, which occurred daily as a result of ion-exchange regeneration at the Plutonium-Uranium Extraction Plant.

Assessment monitoring between 1990 and 1995 concluded that the ditch contaminated groundwater with the nondangerous constituents calcium, sodium, and sulfate, which contributed to elevated specific conductance. Because the contaminants are nondangerous, the site reverted to detection monitoring. Specific conductance subsequently declined, and in 1998, all indicator parameters were below the critical mean values.

216-B-3 Pond. This former pond consisted of a main pond and three expansion ponds (216-B-3A, 216-B-3B, and 216-B-3C). The main pond began operating in 1945 and the expansions were built in the 1980s. In 1994, the main pond ceased operating, and the waste streams were rerouted to the 216-B-3C Expansion Pond and the 200 Areas Treated Effluent Disposal Facility. The main pond was filled with clean soil, and the expansion ponds were clean-closed (i.e., deemed free of dangerous waste and no longer regulated under RCRA). In August 1997, waste streams received by the expansion pond were diverted to the 200 Areas Treated Effluent Disposal Facility, thus ending operation of the B Pond system. In the past, B Pond received liquid waste from B Plant and the Plutonium-Uranium Extraction Plant, consisting of chemical sewer waste, cooling water, and steam condensate. These waste streams contained aluminum nitrate, nitric acid, potassium hydroxide, sulfuric acid, tritium, and other acids. In its later years, B Pond received nondangerous, nonradioactive effluent primarily from the Plutonium-Uranium Extraction Plant and B Plant.

During 1998, B Pond was monitored under an interim-status detection program. Critical mean values of the indicator parameters were not exceeded. The only contaminants consistently detected in groundwater that could be attributed to B Pond operations were nitrate and tritium; however, these constituents have shown downward trends since monitoring began at B Pond.

216-B-63 Trench. This trench received liquid effluent from the B Plant chemical sewer from March 1970 to February 1992. The liquid effluent consisted of a mixture of steam condensate and raw water. Past releases to the trench also included sulfuric acid and sodium hydroxide solutions. Radioactive soils were dredged from the trench in August 1970, but no records exist of radioactive waste disposal to the trench.

Groundwater monitoring continues to show no evidence that dangerous nonradioactive constituents entered the groundwater from this trench. No indicator parameters (pH, specific conductance, total organic carbon, or total organic halide) were exceeded in 1998.

216-U-12 Crib. This crib received wastewater containing dangerous chemical wastes and radionuclides from April 1960 until February 1988. This facility has been in the groundwater quality assessment phase of monitoring since 1993. Site-specific waste indicators include gross alpha, gross beta, iodine-129, nitrate, technetium-99, and tritium. Iodine-129, nitrate, technetium-99, and tritium are detected consistently in groundwater. The findings of the first two phases of the assessment monitoring program indicate that the crib is a source of nitrate and technetium-99 detected in the downgradient wells (PNNL-11574). Nitrate concentrations downgradient of the crib are >10 times the average background value in the upgradient well.

One new well was installed in 1998 to replace a well that is nearly dry as a result of the declining water table.

216-S-10 Pond and Ditch. The facility consisted of an open, unlined ditch and an open, unlined percolation pond. The pond and ditch

received radioactive and dangerous chemical waste from the Reduction-Oxidation Plant from 1951 until 1985, when the pond and the lower part of the ditch were decommissioned and backfilled. The upper part of the ditch continued to receive nondangerous, unregulated wastewater from 1985 through 1991.

All indicator parameters (pH, specific conductance, total organic carbon, and total organic halide) were below their respective critical mean values in 1998.

Chromium continued to be elevated in well 299-W26-7, reaching 576 mg/L in December 1997 (there are no 1998 chromium data). This well is upgradient of the pond, but may have been affected by artificial recharge when the pond was active. The source of the chromium contamination is uncertain, but is possibly related to the pond or to earlier disposal to upgradient facilities.

6.1.7.4 200 Areas Low-Level Burial Grounds

The low-level burial grounds are divided into five low-level waste management areas in the 200 Areas (see Figure 6.1.12). However, Low-Level Waste Management Area 5 has not been monitored for groundwater since 1996 because the burial ground never received waste. The remaining low-level waste management areas are in the indicator parameter phase of RCRA groundwater monitoring.

Low-Level Waste Management Area 1. This waste management area consists of the 218-E-10 Burial Ground. Disposal activities began in 1960 and continue today. Materials placed in this facility are primarily failed equipment and mixed industrial waste from the Plutonium-Uranium Extraction Plant, B Plant, and N Reactor.

Specific conductance exceeded the critical mean value in one downgradient well in December 1998. The higher-conductivity groundwater is believed to have originated in other 200-East Area facilities. The Washington State Department of Ecology was notified of the exceedance and its probable source, and the waste management area remains in detection monitoring. No other indicator parameters exceeded background values, and there is no evidence of any contaminant contribution from this area.

Low-Level Waste Management Area 2. This waste management area includes all of the 218-E-12B Burial Ground, which has been in use since 1968. The waste consists primarily of miscellaneous dry waste and submarine reactor compartments. Parts of two trenches contain transuranic waste.

In 1998, specific conductance exceeded the critical mean established for this area as a result of increases in calcium, nitrate, and sulfate, which are not regulated constituents in groundwater. Because the increase occurred in an upgradient well, assessment monitoring is not required. Total organic halides exceeded the critical mean in a downgradient well in November 1998, but the high value is believed to be erroneous and is being investigated. Values for iodine-129 were above the 1-pCi/L drinking water standard in several wells along the southern boundary of this area. However, this is related to the widespread iodine-129 plume beneath the 200-East Area, and there is no evidence of groundwater contamination from this waste management area.

Low-Level Waste Management Area 3. The 218-W-3A, 218-W-3AE, and 218-W-5 burial grounds make up this area. The 218-W-3A Burial Ground began accepting waste in 1970 and received primarily ion-exchange resins and failed equipment (e.g., tanks, pumps, ovens, agitators, heaters, hoods, vehicles, accessories). The 218-W-3AE Burial Ground began operation in 1981 and contains low-level and mixed waste, including rags, paper, rubber gloves, tools, and industrial waste. The 218-W-5 Burial Ground first received waste in 1986, and contains low-level and low-level-mixed waste, including lead bricks and shielding.

Carbon tetrachloride and nitrate are consistently above their drinking water standards of 5 μg/L and 45 mg/L, respectively, in monitoring wells in this waste management area. However, the elevated values can be attributed to contaminant plumes originating to the south of the area. There appears to be no groundwater contamination directly attributable to this waste management area, and the critical mean values for indicator parameters were not exceeded in 1998.

Low-Level Waste Management Area 4. This area consists of the 218-W-4B and 218-W-4C Burial Grounds. The 218-W-4B Burial Ground first received waste in 1968 and contains mixed and retrievable transuranic waste in trenches and caissons. One caisson is believed to contain mixed waste. Wastes were first deposited in the 218-W-4C Burial Ground in 1978 and were classified as transuranic, mixed, or low-level and included contaminated soil, decommissioned equipment, and remote-handled transuranic waste.

Groundwater near this waste management area is being remediated as part of the 200-ZP-1 Operable Unit. Water is pumped from wells located east of this waste management area, treated, and injected into wells located west of the waste management area. Consequently, the direction of groundwater flow is now from west to east across the site. The groundwater monitoring network was revised in 1998 to reflect the current flow direction. Network modifications also were needed to accommodate declining water levels beneath the area. Statistical evaluation of the upgradient/downgradient comparison values has been suspended until the flow regime stabilizes following pump-and-treat activities. Semiannual sampling continues during this time to determine when stabilization occurs and to maintain continuity in the database.

6.1.7.5 Liquid Effluent Retention Facility

This facility consists of three, lined, surface impoundments (basins) located east of the 200-East Area and serves as temporary storage for condensate from the 242-A Evaporator. Constituents detected in the effluent stream from the 242-A Evaporator were acetone, aluminum, ammonium, 1-butanol, 2-butanone, tritium, strontium-90, ruthenium-106, and cesium-137.

The facility is subject to final-status monitoring. Until the final-status monitoring plan is approved by the regulators, the site continues to operate under the existing interim-status plan. The indicator parameters (pH, specific conductance, total organic carbon, and total organic halide) were not exceeded in 1998. However, in January 1999, specific conductance exceeded its critical mean in one downgradient well. Tritium, which is present in site effluent, is not elevated in downgradient wells, so the source of the high conductivity is not this facility. The Washington State Department of Ecology was notified of the exceedance, and the site remains in detection monitoring.

6.1.7.6 300 Area Process Trenches

The 316-5 Process Trenches are two unlined trenches that were used for the disposal of liquid wastes generated in the 300 Area, beginning in 1975, and received uranium and other radioactive and chemical constituents. From 1985 through 1991, the trenches received nondangerous effluent, and all discharges ceased in 1991.

The site is monitored under a final-status corrective-action program. Until the corrective-action plan is approved, the final-status compliance

monitoring program remains in effect. In 1998, monitoring continued to show elevated levels of uranium downgradient of the trenches. Trichloroethylene exceeded the drinking water standard in two deep downgradient wells, and cis-1,2-dichloroethylene exceeded the drinking water standard in one deep well. A plume of tetrachloroethylene appeared in 1998, with concentrations increasing and decreasing rapidly. The highest concentration was 38 mg/L in well 399-1-17A in July 1998. Levels declined rapidly and the concentration was only 3 mg/L in December 1998. Wells farther downgradient of the trenches reached peak concentrations somewhat later in the year. Although tetrachloroethylene was accidentally discharged to the trenches in 1982 and 1984, the trenches have not been used since 1994. Therefore, the 1998 plume was not due to a recent discharge. Furthermore, the sudden and wide lateral extent of the plume indicates it did not originate at a point source. The most likely source is residual vadose-zone contamination near the trenches that was mobilized by high-river levels in 1996 and 1997.

6.1.7.7 Nonradioactive Dangerous Waste Landfill

The former Nonradioactive Dangerous Waste Landfill (Central Landfill) in the 600 Area southeast of the 200-East Area received waste from 1975 through 1985 that included asbestos, miscellaneous laboratory waste, solvents, paints, sewage, sulfamic and other acids, batteries, battery acid, and mercury. The site is in the indicator parameter phase of groundwater monitoring. None of the indicator parameters (pH, specific conductance, total organic carbon, or total organic halide) exceeded critical mean values during 1998. Chlorinated hydrocarbons were detected in a few wells at concentrations below their respective drinking water standards. Some constituents (e.g., 1,1,1-trichloroethane, trichloroethylene) are thought to be the result of vadose zone vapor transport from the adjacent Solid Waste Landfill, while others (e.g., carbon tetrachloride, chloroform) may have originated in the Nonradioactive Dangerous Waste Landfill. Iodine-129, nitrate, and tritium contamination is also present in some wells, but is part of large plumes originating in the 200-East Area.